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Vol. XXVII, Parts III & IV December 1944

NOTES ON BRITISH HYPHOMYCETES

By G. R. BISBY, *Imperial Mycological Institute, Kew*

(With 3 Text-figures)

The List of British Hyphomycetes (Wakefield & Bisby, 1941, with references) had to include many names of doubtful status. Some of these names, or the specimens on which they are based, are now considered more critically.

It is evident that the bases for distinguishing species of fungi may and should vary with different groups. It is convenient to name parasites on morphology plus host so that, for example, few of the 137 names of *Ovularia*, *Cercospora*, and *Ramularia* in the List need elimination. Most mycologists would object to a taxonomy which required identification of such fungi on morphology alone.

Saprophytes have frequently been named on morphology plus substratum. Though that practice has become less common, little effort has yet been made to reduce such superfluous names to synonymy. Many fungi have been named on morphologic distinctions so slight as to prove confusing; that is, on distinctions which do not allow for variation within a species.

TRICHODERMA. Five years ago (1939) I considered the taxonomy of *Trichoderma*; had I tried to distinguish a score of species, I would now have a few more to propose for cultures that have arrived since. But further study, recent literature, and views of correspondents only strengthen my opinion that all the variants are best considered to belong to one species, *T. viride* Fr. There are, however, two facts that need explanation: (1) *T. viride* is the conidial state of *Hypocrea rufa* and apparently also of *H. gelatinosa* (I now find that von Höhnel (1904) reported it to be a state of at least two species of *Hypocrea*), yet (2) what seems to be the same *Trichoderma* occurs around the world in soil and as a common mould, though in many areas *Hypocrea* is unknown, if not definitely absent.

Since an isolation of *Trichoderma* maintains many of its characteristics during months or years in culture, I interpret *T. viride* to be a species made up of a number of slightly different strains. Two names may, then, be removed from the British List: *T. Koningi* Oudem., a synonym of *T. viride*, and *T. album* Preuss which, to judge by the figures and description of the one British record, was an *Aleurisma*.

STACHYBOTRYS shows even greater variability than does *Trichoderma*, but much of the variation appears in a single culture during a month or two of development. As I have reported (1943), there seems to be but one species of *Stachybotrys* (*S. atra* Corda) in Britain, and seven names can be eliminated—five under *Stachybotrys*, *Synsporium biguttatum* Preuss, and *Aspergillus alternatus* Berk. (= *Periconia alternata* (Berk.) Sacc.).

PENICILLIUM. Lumping of species can of course be carried too far; witness '*P. glaucum* Link, the common green mould' of a few earlier authors (see Thom, 1940). In its place hundreds of specific names have now accumulated; evidently too many, since few mycologists can identify with certainty most isolations of *Penicillium*. There are sixty-six names in the British List.

One need not be an expert on *Penicillium* to eliminate some of these names. On the type specimen of *P. abnorme* B. & Br. (on *Trientalis*, Scotland) someone has written '? conidial state of *Tuburcinia Trientalis*', and that seems the best way to get rid of the name. It is true that Berkeley's sketch does not suggest the conidial state; but it is also true that it does not suggest a *Penicillium*, that there is nothing resembling it evident on the leaves now, and that *Tuburcinia Trientalis* is present.

The names *Penicillium bicolor* Fr., *P. candidum* Fr., *P. crustaceum* Fr., *P. Fieberi* Corda, *P. glaucum* Auct., *P. ovoideum* Preuss, *P. pruriosum* Salisb., *P. quadrifidum* Salisb., *P. silvaticum* Oudem., and *P. sparsum* Grev. should be eliminated because the names are now meaningless and any specimens associated with them probably unidentifiable. For example, there is an ample collection made in 1894 and determined as '*P. pruriosum* Salisb. Developed in a bottle of medicine taken (in part) by W. B. Hemsley...'. This is another example of determining a fungus by its substratum.

I have not seen Sowerby's drawing upon which *P. macrosporum* B. & Br. is based, but the four-word diagnosis 'Aurantiacum, sporis globosis maximis' seems sufficient to eliminate it from the genus. *P. coffeicolor* B. & Br. is no doubt a *Scopulariopsis*, as Thom suggests. The spores are roundish, 7–8μ, truncate and with a basal ring; they remain smooth. *Penicillium megalosporum* B. & Br. is possibly a *Scopulariopsis*. The type specimen consists of a bit of white mould with smooth, hyaline spores 10–15μ in diameter, or sometimes oval and up to 20μ long. A second specimen on old bark, coll. C. E. Broome, March 1872, now bears traces only of the fungus, but has a sketch by Berkeley which would do for *Scopulariopsis*.

Berkeley's figure of *Penicillium subtile* Berk. suggests *Sporendonema Salicis* Bain.; but time has obliterated so many of the morphologic features of the type specimen that it is unsafe to add the latter name as a 'new British record'.

Fifty years ago Massee (1893) had thirteen British species of *Penicillium*, i.e. most of those just mentioned. Not one of the thirteen is now considered a recognizable member of the genus. It is time we eliminated these names.

CLADOSPORIUM. Genera of Hyphomycetes which include both saprophytic and parasitic species are likely to have become especially uncertain taxonomically. *Cladosporium* provides a good example. *C. herbarum* Fr., which should certainly be designated lectotype of the genus, is 'perhaps one of the most cosmopolitan of Fungi...certainly with us it is the commonest of all moulds' (Cooke, 1877). Nevertheless Cooke, along with other mycologists, described 'new species' of *Cladosporium* on different substrata and hosts, until there are now some 300 names, twenty-six of which are recorded for Britain; but no one is yet sure of the characters of *C. herbarum*. The early descriptions (see Fries's *Systema*, for example) stressed the

macroscopic characters and said little about the spores except that they were olivaceous, catenulate, and deciduous. Link and Nees described the spores as globose, and Nees figured short chains of roundish spores rising from the hyphae; but the microscopes of those days did not permit accurate observation of such small spores. I do not know whether there is a specimen in the Persoon, Link, or Fries Herbarium that could be designated lectotype of *C. herbarum* but, since such old specimens are likely to be unsatisfactory, I am suggesting below that one culture be considered a 'standard'; or, if it seems advisable, a lectotype, until more knowledge, including that of the perfect state or states, permits reconsideration of the genus.

One source of confusion with *Cladosporium* is Saccardo's disposition of it in the Didymosporae, for most of the conidia are one-celled (and the fungus is often referred to *Hormodendrum*), a few are two- or three-celled. Other characters which distinguish *Cladosporium* are the acropetal production of dry spores in dendroid chains which break up at a touch, and the dense colonies generally olivaceous green.

I have not studied cultures or specimens of the five species of *Cladosporium* recorded as definitely parasitic to plants in Britain, but *C. cucumerinum* Ell. & Arth., *C. fulvum* Cooke, and *C. Paeoniae* Pass., are accepted as distinct members of the genus. *C. Pisi* Cug. & Macch., with one report, may (I gather from Moore, 1943) have been a strain of *C. herbarum*. *C. carpophilum* Thüm. is referred to *Fusicladium* by British plant pathologists.

No one can collect fungi, or grow them in culture, without encountering too much saprophytic *Cladosporium*. Brooks and Hansford (1923) studied many strains, all of which they referred to *C. herbarum*. During the last few months I have studied a number of cultures of *Cladosporium*, mostly British and all probably saprophytes, and I am inclined to agree with Brooks and Hansford. G. Smith states (1942): 'Until such time as someone sorts out the genus according to modern ideas, it is probably best to lump together all the common, green saprophytic forms as *C. herbarum*.' I believe that Smith would agree that the modern idea should not make the taxonomy of *Cladosporium* like that of *Penicillium*.

In order to supplement the work of Brooks and Hansford, and others, I selected a culture which seemed about average for *Cladosporium herbarum* (as generally interpreted) and made single-spore isolations. One of these isolations is now described. I do not know its nuclear or genetic constitution, but I assume that a single-spore culture and several transfers promptly made from it can be considered to represent one individual. The original isolation (possibly also from a single spore) was made from fallen leaves of *Arundo* collected in the Bamboo Garden, Kew, in the spring of 1943; the single-spore culture, made in September, 1943, had these characters:

A colony, during the first week or two on standard agar media at 20–25° C., grows 1–2 mm. in radius per day, thereafter increasingly slowly in Petri dishes; the surface of the colony up to about 1 mm. from the margin is olive green and powdery from the abundant conidiophores and conidia; older cultures may produce pale, sterile tufts or overgrowths. The young hyphae are nearly hyaline, 2·5–3 μ wide, made up of thin-walled cells about 20–40 μ long, contents granular; many hyphae in cultures two or

three weeks old are olive brown, up to 8μ wide, cell walls smooth and up to 1μ thick, cells about 8–20μ long, generally with rows of rounded guttulae. A crust-like growth develops at the surface of the agar, and other hyphae may penetrate to a depth of about 1 cm. The superficial hyphae start, when a few hours old, to develop conidiophores which rise as more or less upright branches. The young and still lengthening conidiophore forms one to three buds; each bud becomes a spore which may remain small and form other spores in acropetal succession, or may grow longer, at the same time forming one to three young spores at the apex (Fig. 1), and so on. When mounted in liquid the spores all disarticulate and nothing is seen of the conidiophore except the primary branch from the parent hyphae, with slight apical projections where the first spores were attached, and the longer spores which were the 'links' forming the dendroid conidiophore. A culture a week old has about 90% of the spores 4–7 × 3–4μ, oval or globose, smooth (as seen by ordinary magnifications) except for one or two slight projections representing previous attachments. Nearly all the other 10% of the spores are also one-celled, but up to 30μ long and 7μ wide, commonly slightly roughened; about 1% of these longer spores (i.e. 0·1% of all spores) are 1-septate, and a very few 2-septate.

A transfer of this culture, which I suggest as a 'standard culture' of the species, has been sent to the Lister Institute. It will probably retain most of its characteristics for a few years. Dried cultures, which for many fungi have more permanent value than living, have been deposited in the herbaria of the Imperial Mycological Institute, Royal Botanic Gardens at Kew, U.S. Department of Agriculture, Washington, and the Central Experimental Farm, Ottawa.

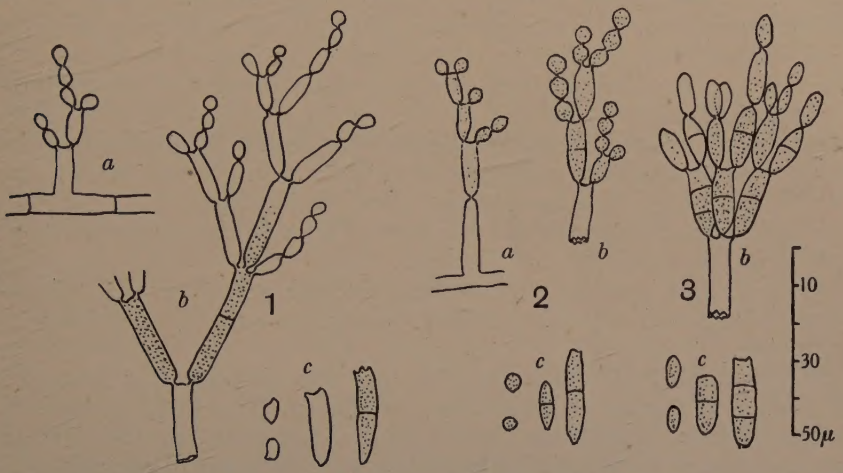
Amongst the cultures of *Cladosporium* studied during 1943 was one which originated as a contaminant from the air. Since it appeared distinctive I made single-spore isolations, one of which (i.e. another individual) had these characters: rate of growth, colour of colonies, and other macroscopic features not noticeably different from the *Arundo* 'individual', but the microscopic features differ in these observed respects: (1) older hyphae do not exceed 5μ in diameter and (2) lack guttulae; (3) about 90% of the spores are roundish, 3–5 × 3–4μ and (4) slightly roughened as seen under ordinary high power (Fig. 2). The remaining 10% of spores are similar to those from *Arundo*, except in being more roughened; they are up to 25 × 4μ, and about 1% of them (0·1% of all) are two-celled. A transfer of this culture has also been sent to the Lister Institute, and dried cultures to the herbaria mentioned above.

Meanwhile a culture arrived from Canada, from which I made single-spore subcultures. An 'individual' of this fungus differs from the *Arundo* isolation in these respects: (1) rate of growth somewhat slower on most media; (2) about 75% of the spores are one-celled and 7–15 × 4–5μ, a few are smaller but (3) all spores are noticeably roughened; (4) nearly 25% of the spores are two-celled and 13–25 × 4·5–6μ; a very few are three-celled (Fig. 3). It may be remarked that if *Cladosporium* belongs to the Didymosporae, this culture comes nearest that genus.

Some may consider that I had three distinct species—or even, as

mentioned below, fungi belonging to three genera. Certainly one can distinguish these individuals, but not even amongst the Fungi does each recognizable individual necessarily belong to a different species. I am trying to induce these and other strains to produce perfect states; only two reports of such a state, called *Sphaerella Tulasnei* Jancz., are known to me, and until more are known it may be best to suspend judgement.

Meanwhile it seems to me better to refer all the British cultures of saprophytic *Cladosporium* I have studied to the one species *C. herbarum*, for the following reasons: (1) there is much similarity in the ensemble of characters, including the range of spore size and shape (Figs. 1, 2); (2) strains not figured show intergradations and different variations; (3) on various media, including potato and carrot plugs, agar with 20 % sucrose



Figs. 1–3. *Cladosporium*. 1, 'standard' *C. herbarum* from a dead leaf of *Arundo*, Kew. 2, a laboratory weed; many spores roundish, all slightly roughened. 3, a culture from Canada: the spores soon become slightly rough, and many develop cross septa. Each letter *a* represents a very young conidiophore and spores, *b* part of a somewhat older conidiophore, and *c* the range of spores. All × 500. The stippling represents roughness.

or with 25 or 50 % salt (NaCl), different strains grew similarly; (4) many other species of moulds are variable, and though it seems necessary to recognize species on slight morphologic grounds in such genera as *Aspergillus* and *Penicillium*, I see no such necessity with *Cladosporium*; (5) the cultures I studied probably could not be identified definitely with existing species (other than *Cladosporium herbarum*), and it seems superfluous to add more new names to the 300 now extant.—Possibly it may prove desirable to recognize varieties or forms of *C. herbarum*.

Old herbarium specimens of *Cladosporium* are generally unsatisfactory, but the following notes on specimens representing some of the names in the British List are given for what they are worth.

The type specimen of *Cladosporium Algarum* Cooke and Massee seems to be *C. herbarum*. It is true that some of the spores are rough and 2- or 3-septate (Cooke and Massee later transferred the epithet to *Heterosporium*),

but I do not think the fungus deserves even specific rank. It is on *Laminaria*, which is figured by Brooks and Hansford bearing *Cladosporium herbarum*.

C. Aphidis Thüm., *Mycotheca universalis* 672 (the type), is also apparently *Cladosporium herbarum*, despite von Thümen's statement 'a *Cl. herbarum* haec species certe diversissima est!' Petch (1932) considers that the *Cladosporium* on Diptera is probably *C. herbarum* growing saprophytically.

C. brachormium B. & Br. and *C. epibryum* Cooke & Massee are represented by no specimen in the *Cladosporium* folders at Kew. The descriptions leave one in doubt. Nor is there material of *C. orchidearum* Cooke & Massee, but its descriptions and Cooke's statement (1906) 'we are convinced that it only makes its appearance on dead or diseased tissue' indicate *C. herbarum*.

The type specimen of *C. Kniphofiae* Cooke, on old mouldy leaves, evidently bears *C. herbarum* and other saprophytes. *C. juglandinum* Cooke I take to be *C. herbarum* also. The one specimen of *C. fasciculare* Fr., and the two of *C. nodulosum* Corda, marked British in Kew Herb. are, in my view, *C. herbarum*. I see nothing distinctive about the figures and description of *C. Lycopersici* Plowr.

Berkeley's specimen marked *C. lignicola* Corda is a fungus such as Corda figures and, as Berkeley suggested, it is not a *Cladosporium*; nor, I think, is the fungus called *C. myrmecophilum* (Fres.) Bayliss Elliott.

No British material or figure was seen of a half dozen other 'species' of *Cladosporium* recorded for this country.

I propose that, pending further data, twenty-two names of *Cladosporium* be struck from the British list, leaving four species—three parasites and one saprophyte.

HORMODENDRUM Bonorden (1851) was proposed for four species described and placed in *Penicillium* by Corda. The first, *Hormodendrum olivaceum* (Corda) Bon., is the type of the genus, for the three other epithets were transferred to *Spicaria* by Harz (1871). There is still much doubt as to the identity of *Hormodendrum olivaceum*, said to have spherical conidia, and no type material is reported in Corda's herbarium. It seems likely, however, that *Hormodendrum* is a synonym of *Cladosporium* (see Thom, 1940). At any rate, the description and figures of the one British record of *Hormodendrum olivaceum* suggest *Cladosporium herbarum* which, as Brooks and Hansford note, may have globose spores; see also Fig. 2 above, which I cannot believe represents a distinct genus. It is generally accepted that *Hormodendrum cladosporoides* (Fres.) Sacc. refers to *Cladosporium herbarum* in the amerosporous condition.

There is no British specimen in the *Hormodendrum* folder at Kew. *H. Hordei* Bruhne is transferred to *Cladosporium herbarum* as a form by Ferraris (1914), who recognized no Italian species of *Hormodendrum*. As for *H. chartarum* (Cooke) Grove, described as a *Penicillium* by Cooke and placed in *Haplographium* by Saccardo, no specimen was found in any folder; Cooke's figures and description baffle me, as they have others. So I take it that we can cross out all British records of *Hormodendrum*.

HETEROSPORIUM Klotzsch ex Cooke (1877*a*) was characterized as follows: 'Flocci erecti, septati, flaccidi. Sporis heterogenis, deciduis, demum multiseptatis, subhyalinis, echinulatis vel granulatis. This genus

approaches *Cladosporium* in habit, rather than *Helminthosporium*, and probably also in the spores being at first concacenate [*sic*]. All the species yet known are parasitic on living or fading leaves.' Although Cooke attributed the name to Klotzsch, he cited only a Phillips specimen for *H. Ornithogali* Klotzsch ex Cooke, the type species of the genus; but in another paper published about the same time (1877) he says Phillips's specimen is identical with Klotzsch's [*Herb. vivum Mycol.*, Cent. 1, No. 69, 1832]. The other exsiccatus issued by Klotzsch—No. 67, *H. maculatum*—was stated by Cooke to be 'only a *Cladosporium*'; but, in 1889, in his haste to supply Saccardo with 'omitted diagnoses' he gave the first description of *Heterosporium maculatum* Klotzsch ex Cooke.

The parasitic species of *Heterosporium* are becoming known (see Dowson, 1913; Jacques, 1941). The perfect states of four species have been described as *Didymellina macrospora* Kleb., *D. Dianthi* C. C. Burt, *D. poecilospora* McWhorter, and *D. Ornithogali* Jacques. The seven species recorded in Britain as parasites respectively on *Allium*, *Dianthus*, *Iris*, *Narthecium*, *Ornithogalum*, *Syringa*, and *Spinacia* are, so far as I know, good species.

One or two questions of nomenclature need mention. Jacques (1941) proposed the combination *Heterosporium Iridis* (Fautr. & Roum. [1891]) Jacques for the fungus commonly called *H. gracile*. It is true that the epithet *gracile* comes from Wallroth's *Helmisporium gracile*, which Saccardo (*Sylloge*, IV, 1886) transferred to *Brachysporium*. A few pages further on Saccardo proposed '*Heterosporium gracile* (Wallr.?) Sacc. *Helminthosporium gracile* Wallr. Fl. crypt. n. 1503 (?)', followed by a 'modern' diagnosis. Ramsbottom (1915) concluded that the binomial should be cited as *Heterosporium gracile* Sacc. [1886]. Although the Rules of Nomenclature have been revised since 1915, I think that *H. gracile* Sacc. is still right. Saccardo had already made *Helmisporium gracile* Wallr. the type of *Brachysporium gracile* (Wallr.) Sacc.; he did not use Wallroth's diagnosis for the *Heterosporium*, and the use of '?' obviates the necessity of considering the binomial a homonym. The Plant Pathology Committee of the British Mycological Society has decided in a comparable case that '*Calonectria graminicola* (B. & Br.) Wollenw. n.n. Synonymy: ? *Nectria graminicola* Berkeley and Broome' can be cited '*Calonectria graminicola* Wollenw.'

Lind (1913) found *Heterosporium Magnusianum* Jaap [1902] to be antedated by *Napicladium ossifragi* Rostr. [1901], and made the combination *Heterosporium ossifragi* (Rostr.) Lind.

Dr Jacques had sent very useful dried cultures of *Heterosporium* to Kew, and kindly sent me fresh transfers, which I have examined in comparison with other cultures in an effort to ascertain whether or not there are saprophytic moulds, in Britain or elsewhere, which should be referred to *Heterosporium*. The seven species studied by Jacques are all parasites (and faculative saprophytes) with the possible exception of *H. Robiniae* Kabát & Bubák, which is recorded on fallen leaves; but at any rate it seems to be restricted to *Robinia*, in Europe and North America.

Jacques points out that the type species, *Heterosporium Ornithogali*, belongs to an intermediate group which has spores like certain species of *Helminthosporium* except in being rough and often catenulate. *Heterosporium*

variabile Cooke, on the other hand, approaches *Cladosporium* very closely. Jacques also notes that all the species he studied produced stromata in agar.

The applicability of the term 'stroma' to the crust of interwoven hyphae in the agar depends somewhat on definition. One finds the same sort of growth in cultures of *Cladosporium herbarum*, where it has no evident relationship with any sort of spore production. However, Jacques's culture of *Heterosporium Ornithogali* has now practically ceased to form conidia, but forms instead sterile perithecial primordia upon the crust of hyphae which might truly be called a stroma. *H. variabile* still produces conidia abundantly, though it has been many years in culture; in this it shows another similarity with *Cladosporium*.

Any saprophytic species of *Heterosporium* should have a considerable proportion of phragmospores, all spores should become rough, and one would expect them to be catenulate, at least in part. Is there such a saprophyte in Britain?

It is true that *Heterosporium maculatum*, distributed by Klotzsch in 1832, was thought to be a saprophytic species, that about forty more have been described as saprophytes, and one (*H. Betae* Dowson, 1913) studied in culture. The type exsiccatus of *H. maculatum* (on *Typha* and, fide Cooke, apparently *Sparganium*) at Kew has spores $15–25 \times 6–10\mu$, roughened, commonly 1-septate, some 0-, 2-, or 3-septate, fairly symmetrical. Overholts (1929) figured spores from this collection of Klotzsch's, found them $13–19 \times 6–7\mu$, and reported the fungus from Missouri on *Typha*.

No one, so far as I know, has studied *Heterosporium maculatum* in culture, and I have not yet found living specimens on *Typha*. I made a number of isolations from fallen leaves and culms of Monocotyledons from the Bamboo Garden at Kew, and though I obtained plenty of *Cladosporium herbarum*, there was nothing I could consider *Heterosporium*. About that time I saw the culture from which Fig. 3 was made, and my first reaction was that it represented the saprophytic *Heterosporium* I sought. It is very similar to the *H. Betae* described and figured by Dowson. However, upon more sober thought, I concluded that the fungus could not be considered generically different from *Cladosporium*.

The type (and only) specimen of *Heterosporium Auriculae* Cooke consists of one small leaf bearing a bit of mould with spores $10–20 \times 6–7\mu$, rough, 0–1-septate. *H. epimyces* Cooke & Massee, on very mouldy old pilei of *Boletus*, etc., has similar spores and other sorts as well. If both had been marked *Cladosporium herbarum*, I do not think mycology would have suffered. No specimen of *Heterosporium Laricis* Cooke & Massee was found, but if the spores are '$50–60 \times 20\mu$' it is something different.

The type specimen of *Heterosporium Typharum* Cooke & Massee, and British specimens marked *Cladosporium Typharum* Desm., resemble *Heterosporium maculatum*; this is not surprising, since all are on *Typha*. *Heterosporium minutulum* Cooke & Massee, on a palm, may possibly be the same fungus.

This is not a monograph of *Heterosporium* and *Cladosporium*; I am merely trying to evaluate some of the names of British Hyphomycetes. I suggest

as a hypothesis that there may be one saprophytic species of *Heterosporium* here, instead of the four or five reported. I hope someone will study this fungus from *Typha*. I have been calling it *Heterosporium maculatum*, though that is not the earliest valid name.

RHINOTRICHUM has recently been monographed by Linder (1942, under the name *Oidium*). His identifications of the species in the British list are:

Rhinotrichum aureum Cooke & Massee is *Amblyosporium Botrytis* Fres.
Rhinotrichum decipiens Cooke is a basidiomycete.
Rhinotrichum decolorans Cooke is an *Aspergillus* or *Penicillium*.
Rhinotrichum Opuntia B. & Br. is a *Phymatotrichum*—a genus not previously reported from Britain under that name.
Rhinotrichum ramosissimum Berk. & Curt. is not recorded from Europe by Linder.
Rhinotrichum Thwaitesii B. & Br. is *Botrytis splendida* (Schw.) Sacc., a 'new record' for Britain. The identity of *Rhinotrichum Thwaitesii* var. *fulvum* Grove was apparently not ascertained. I find no specimen at Kew.

Linder accepts the four other British species of *Rhinotrichum* (sensu Auct.).

SCLEROTIUM. Of the twenty-eight species of *Sclerotium* in the British List, I would eliminate twenty-two. It is contrary to the Rules and seldom useful to maintain names for sclerotial states after their perfect states become well known. *S. complanatum* Fr. and *S. scutellatum* Fr. belong to *Typhula phacorrhiza*, *Sclerotium semen* Fr. to *Typhula variabilis* (see Remsberg, 1940), and several others are also states of Hymenomycetes. There is no British specimen in the *Sclerotium* folders at Kew of *S. nervale* Fr., *S. populinum* Fr., *S. quercigenum* Berk., or *S. salicinum* Fr. Few mycologists to-day would attempt to name sclerotia such as those and *S. neglectum* Berk. until they had developed their perfect states. The only names of *Sclerotium* in Britain which seem to merit independent status are *S. cepivorum* Berk., *S. Gladioli* Massey (its perfect state is known, but not here), *S. muscorum* Fr., *S. rhizodes* Auersw., *S. stellatum* Horne, and *S. Tuliparum* Kleb.

RHIZOCTONIA. The record of *Rhizoctonia Allii* Fr. should be deleted from the List. There is no British specimen at Kew, nor is there a definite British record. *R. Crocorum* Fr. and *R. Solani* Kühn are useful names—especially since mycologists have not decided what to call the perfect state of the latter: a recent name for that state is *Pellicularia filamentosa* (Pat.) Rogers (1943)—but obviously a species should not be counted more than once, because it has two (or sometimes three or more) named states.

SPOROTRICHUM. Mycologists will eventually have to discard many of the names in certain genera and continue with such species as are definitely recognizable. *Sporotrichum* will require some such treatment. For more than a century names have been applied, often to nondescript fungi of various sorts that cannot now be recognized from the descriptions, nor even from such figures and type specimens as exist.

Vuillemin (1910, 1911) considered that species of *Sporotrichum* should possess true conidia borne on sterigmata. He did not specify a type species,

though he considered *S. chrysospermum* Harz (1871) to belong to the genus. Grove's figures of a British collection of this species resemble Harz's figures. But I do not yet know one of the old species of Link or his contemporaries that might be chosen as lectotype of *Sporotrichum*.

Vuillemin's most important contribution to the *Sporotrichum* problem was the clear recognition that certain species placed in the genus do not form true conidia, but chlamydospore-like asexual spores which he designated aleuriospores. This term he coined from the generic name *Aleurisma*, which he revived for a common fungus identified by him as *A. flavissimum* Link ex Chev. He thought *Sporotricum sulphureum* Grev. might be a synonym. The Royal Botanic Garden, Edinburgh, informs me that no type material of *S. sulphureum* is now to be found. Greville decided later that this name was a synonym of *S. merdarium* Link ex Fr., but that may or may not be true. The specimens in Kew Herb. marked *S. sulphureum* are in part *Aleurisma*: e.g. Berk. Exs. 211; Ellis & Everhart, N.A. Fungi Second Series No. 2963; a collection by Crossland 22 April 1908, which has tufts such as Greville figured. Other specimens labelled *S. sulphureum* are various kinds of moulds with a yellowish colour.

There is no British specimen at Kew marked *Sporotrichum* (or *Aleurisma*) *flavissimum*, though this species has been reported. Some years ago I obtained, from the Centraalbureau voor Schimmelcultures at Baarn, Vuillemin's culture of *Aleurisma flavissimum*. Spore production had become greatly reduced, but the fungus still produced the green colour he described. It should be noted, however, that Vuillemin placed strains with a sulphur yellow colour in the same species.

Sporotrichum carnis Brooks & Hansford and the species of *Geomyces* Traaen belong in the same genus with *Aleurisma flavissimum* sensu Vuill. I have studied the type culture of *Sporotrichum carnis* (and many other cultures of this common fungus), Traaen's type culture of *Geomyces auratus*, and Robak's culture of *G. cretaceus*. These three 'species' and *Aleurisma flavissimum* grow at the same rate—a slow rate for a mould—and show other similarities. What name or names should be applied to them?

The name *Geomyces* has scarcely been used outside Norway. Traaen (1914) described the genus and four species. Robak (1932) studied a dozen or more cultures of *Geomyces*, of which only one (*G. cretaceus*) agreed fully with Traaen's descriptions. Robak, and Traaen on reconsideration, were inclined to think that there were only two species to be considered, *G. auratus* and one other.

Brooks and Hansford (1923) recognized four strains of their fungus, but considered that they represented but one species, *Sporotrichum carnis*. With that view I agree; the alternative would be the naming of scores of 'species' on minor differences. It is true that I have, in the past, occasionally identified a culture as *Geomyces auratus*, but I find that these golden cultures gradually lose their distinguishing colour.

It seems to me best to use the genus *Aleurisma* Link ex Chev. em. Vuill. (conserving it against *Aleurisma* sensu Fries, if that be necessary) for several reasons, one of which is the hope that so early a generic name will retain its priority. Although it is possible that *A. flavissimum* has a range of

variability sufficient to include forms that have been called *Geomyces* and *Sporotrichum carnis*, Vuillemin's stress upon the green colour, and the rather large size he gave for the aleuriospores, seem to mark it as a distinct species. I hereby propose **Aleurisma carnis** (Brooks & Hansf.) n.comb. for the common fungus heretofore called *Sporotrichum carnis*, until a comprehensive study of the taxonomy and nomenclature of *Aleurisma* and *Sporotrichum* may provide another name.

Sporotrichum Malorum Kidd & Beaumont has been transferred to *Phialophora* by McColloch (1942). The one British record of *Sporotrichum cinnamomeum* Wallr. is based on a specimen (Rhodes 4711) that is certainly *Acrostalagmus cinnabarinus* Corda. There is no specimen, marked British, at Kew of *Sporotrichum aurantiacum* Fr., *S. chlorinum* Fr., *S. flavissimum* Fr., *S. lanatum* Wallr., *S. merdarium* Fr., nor *S. olivaceum* Fr., and I doubt that anyone could be sure of the identity of these ancient species, except *S. flavissimum* sensu Vuill. The one British collection marked *S. laxum* Fr. does not agree with the description of that 'species'; those marked *S. geochroum* Fr. and *S. laeticolor* Cooke & Massee are possibly young stages of *Hypoxylon*. *Sporotrichum maritimum* Sutherl. is a very doubtful species; it may be remarked that a fungus is not necessarily a new species because it is on old *Laminaria*.

Of the eighteen names of *Sporotrichum* in the British List, it would seem that only three are recognizable species of the genus: *S. chrysospermum* (Grove's collection, at least), *S. terricola* Grove (perhaps; I have not seen the type and only collection), and *S. Isariae* Petch until mycologists decide what to do with *Sporotrichum*-like fungi with sessile spores. *S. carnis* is transferred to *Aleurisma*, and some of the collections named *Sporotrichum sulphureum* also belong to *Aleurisma*, and may possibly be the same as *A. carnis*. Twelve or thirteen names of *Sporotrichum* in the British List should, in my view, be discarded unless and until someone can tell us what they mean.

TRICHOSPORIUM is a sort of 'dark *Sporotrichum*'. I hopefully looked over the collections at Kew, but the only specimens marked British are one of *Trichosporium fuscum* (Link ex Wallr.) Sacc., which is said to be a state of *Rosellinia aquila* (Fr.) de Not., and one marked '*Trichosporium umbrinum* (Pers.) Lindau' (= *T. Tulasnei* Lindau), which I do not know. It seems evident that some elimination is needed in *Trichosporium*, but I cannot provide it at the moment.

Part of the type collection of *Alliospora Sapucayae* Pim was found at Kew. Mr H. A. Dade finds that the fungus belongs to the *Aspergillus niger* group, as has long been suspected.

Summary

The List of British Hyphomycetes (1941) and Supplement (1942) give a net total of 1218 names. To relieve somewhat this incubus upon mycologists, I propose that ninety-five epithets be eliminated, as follows: two in *Trichoderma*, five in *Stachybotrys*, one each in *Periconia* and *Synsporium*, fifteen in *Penicillium*, twenty-two in *Cladosporium*, four in *Hormodendrum*, four in *Heterosporium*, six in *Rhinotrichum*, twenty-two in *Sclerotium*, one in *Rhizoctonia*,

and twelve in *Sporotrichum*. The generic names *Hormodendrum* and *Synsporium* are to be deleted also, but *Aleurisma* and *Phialophora* may be added. This small beginning, if accepted, reduces the number of British Hyphomycetes to 1123 plus additions made since 1941. It is often as important to get rid of an old name that is a handicap as to add a new one that is 'good'.

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INVESTIGATION INTO THE PRODUCTION OF BACTERIOSTATIC SUBSTANCES BY FUNGI

V. PRELIMINARY EXAMINATION OF THE THIRD 100 FUNGI WITH SPECIAL REFERENCE TO STRAIN VARIATION AMONG SPECIES OF *ASPERGILLUS*

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Introduction

This paper continues the general line of research of four others (Wilkins & Harris, 1942, 1943, 1943*a* and 1944), each of which dealt with an examination of 100 fungi in relation to the production of bacteriostatic substances. The most promising fungi were species of *Aspergillus* and *Penicillium* and subsequent chemical investigation at the Oxford School of Pathology, of crude metabolism solutions supplied by us, resulted in the isolation of the following new substances: From a solution produced by *Penicillium claviforme* Bain, 1718, Chain, Florey and Jennings (1942) isolated a bacteriostatic, though toxic substance, which they named 'claviformin'. Later this was shown by Chain, Florey and Jennings (1944) to be identical with the 'patulin' of Birkenshaw, Bracken, Greenwood, Gye, Hopkins, Michael and Raistrick (1943), from *P. patulum*, and by Hooper, Anderson, Skell and Carter (1944), to be identical with the 'clavacin' of Waksman, Horning and Spencer (1942, 1943), from *Aspergillus clavatus*. The 'clavatin' of Bergel, Klein, Morrison, Moss, Rinderknecht and Ward (1943), isolated from a crude solution supplied by Wiesner (1942), is most probably the same substance. Florey, Jennings and Philpot (1944), have isolated claviformin from a solution produced by *A. giganteus* Wehm. From our metabolism solution of *A. fumigatus* mut. *helvola* Yuill, 5911, Chain, Florey, Jennings and Williams (1943), isolated a powerfully anti-bacterial substance which they named 'helvolic acid'. This differs chemically from the 'fumigacin' of Waksman, Horning and Spencer (1942), produced by *Aspergillus* f. *fumigatus*, as confirmed by Florey, Jennings and Philpot (1944). This is further discussed by Waksman (1944). From our crude solution produced by *A. giganteus* Wehm, 3780, Philpot (1943) isolated a penicillin-like substance which she named 'gigantic acid'. Other metabolism solutions produced to date are being similarly investigated.

Present work

The present paper, in addition to an examination of 100 more fungi, attempts to verify the suggestion which we made previously (1943*a*) that any statement about the bacteriostatic properties of a fungus *species* was of

relatively little significance because the various *strains* of that species might, and usually did, react very differently. This point has been noted by other investigators but, in our opinion, it demands considerable emphasis. We have examined 100 strains distributed among twenty-three species of the genus *Aspergillus* with the object of illustrating strain variation within the species. By the term 'strain' we understand, in general, a fungus that has been isolated by a known person from a recorded habitat, has been identified as a species of *Aspergillus*, has been deposited with a recognized Type Culture Collection such as the Lister Institute, or the Centraalbureau, Baarn, and included in their classified list, e.g.: '*Aspergillus niger* v. Tieghem, 2389., isolated from a case of otomycosis by Pijper and Pullinger, Transvaal, May. 1927.' All the strains used in this work were obtained from the Lister Institute and the 'Lister Number' is assigned to each. The fungi were grown on various kinds of culture media (see later) and after from four to ten days, the metabolism solution was tested for its bacteria-inhibiting properties by the method already described (Wilkins and Harris, 1943) against three representative types of bacteria—*Bacterium coli*, *Staphylococcus aureus* and *Pseudomonas pyocyanea*. The results are given in the following list. The symbol + indicates a positive reaction which gives a zone of at least 4·5 mm. in width and which is described as 'strongly positive'; the symbol + indicates a positive result giving a zone of at least 2 mm. in width, described as 'weakly positive', and the symbol − indicates a negative reaction.

List of fungi examined

	Bact. coli	*Staph. aureus*	*Pseud. pyocyanea*
A. candidus Link			
Strain 3798	−	−	−
„ 5605	−	−	−
A. clavatus Desm.			
Strain 3886	−	−	−
„ 3887	−	−	−
„ 3898	−	−	−
„ 3899	−	+	−
„ 5598	+	+	−
„ 5598A	+	+	−
A. flavus Link			
Strain 793	+	−	−
„ 3358	−	−	−
„ 3891	+	−	−
„ 3897	−	+	−
„ 5603	+	−	−
„ 5603A	+	−	−
A. fumaricus Wehm.			
Strain 2414	−	+	−
„ 3892	+	+	−
A. fumigatus Fres.			
Strain 982	+	+	−
„ 1198	+	+	−
„ 1368	+	+	−
„ 1370	+	+	−
Strain 1371	−	+	−
„ 1372	−	−	−
„ 1373	−	+	−
„ 5600	+	+	−
„ 5600A	+	+	−
A. giganteus Wehm.			
Strain 3893	−	+	−
A. glaucus group			
Strain 1216	−	−	−
„ 1830	+	+	−
„ 2514	−	−	−
„ 3894	−	+	−
„ 5602	−	−	−
„ 5602A	−	−	−
A. luchuensis Inui			
Strain 3896	+	+	−
A. nidulans (Eidam) Winter			
Strain 796	−	−	−
„ 3785	−	−	−
„ 3900	−	+	−
„ 3901	−	−	−
„ 5601	−	+	−
„ 5601A	−	+	−

	Bact. coli	*Staph. aureus*	*Pseud. pyocyanea*
A. niger v. Tieghem			
Strain 308	−	+	−
„ 603	−	+	−
„ 799	+	+	+
„ 1161	+	+	+
„ 1214	+	+	+
„ 2389	+	+	+
„ 2390	+	+	+
„ 2443	+	+	+
„ 3857A	+	+	+
„ 3858A	+	+	+
„ 3902	+	+	+
„ 4030	+	+	+
„ 5604	−	+	−
„ 5604A	+	+	+
A. niger-citricus Wehm.			
Strain 2379	+	+	+
„ 2380	−	−	−
A. ochraceus Wilh.			
Strain 3889	−	−	−
„ 3895	+	+	−
„ 3904	+	+	−
A. Oryzae (Ahlb.) Cohn			
Strain 965	−	−	−
„ 3876	−	−	−
A. repens (Cda.) Sacc.			
Strain 3789	−	−	−
„ 3903	−	−	−
„ 3905	−	+	−
A. restrictus Smith			
Strain 4155	−	+	−
A. Schiemanni (Schiemann) Thom			
Strain 3781	+	+	+
A. species			
Strain 1369	−	+	−
„ 1514	−	−	−
„ 6334	+	+	−

	Bact. coli	*Staph. aureus*	*Pseud. pyocyanea*
A. species (white)			
Strain 3925	−	+	−
„ 3926	−	−	−
„ 3927	−	−	−
„ 3928	−	−	−
„ 3929	−	+	−
„ 3930	−	−	−
„ 3931	−	−	−
A. Sydowi (Bain. & Sart.) Thom & Church			
Strain 1944	−	−	−
„ 3888	−	−	−
„ 3906	−	−	−
„ 3907	−	−	−
„ 3908	−	−	−
„ 3909	−	−	−
A. Tamarii Kita			
Strain 1884	+	+	−
„ 3901	−	−	−
A. terreus Thom			
Strain 3911	+	+	−
„ 5606	−	−	−
A. versicolor (Vuill.) Tiraboschi			
Strain 3791	−	−	−
„ 3912	−	−	−
„ 3913	−	−	−
„ 3914	−	−	−
„ 3915	−	−	−
„ 3916	−	−	−
„ 3917	−	−	−
„ 3918	−	−	−
„ 5607	−	−	−
„ 5607A	−	−	−
A. Wentii Wehm.			
Strain 3919	+	+	−
„ 3920	+	+	−
„ 3921	+	+	−
„ 5608	+	−	−
„ 5608A	+	+	+

From these results, within the limits of the investigation, the following generalizations can be made:

(1) The number of positive fungi is less than the number of negative ones; out of the total of 300 tests, approximately fifty are strongly and fifty weakly positive, whereas approximately 200 are negative.

(2) The strongly positive reactions are the only ones likely to be of therapeutic significance. There are twenty-eight reactions against *Staphylococcus aureus*, sixteen against *Bacterium coli* and nine against *Pseudomonas pyocyanea*, but of these only six strains act against all three types of bacteria. The strains which act against one type of bacteria are relatively few and the bacterium most readily inhibited is *S. aureus*, e.g. in the list, there are fifteen reactions against *S. aureus*, five against *B. coli* and one against *P. pyocyanea*.

(3) Of the positive results, the commonest is a reaction against both *S. aureus* and *B. coli* but with the stronger reaction against *S. aureus*.

(4) Certain species, e.g. *Aspergillus niger*, appear to be wholly positive while others, e.g. *A. versicolor*, appear to be wholly negative, in all strains tested. There is, however, usually a strain variation within the species from strongly positive to negative.

(5) It is established that, with ordinary methods of experimentation, the statement that a 'species' is positive or negative usually depends on the particular strain chosen.

Experimental work

The production of bacteriostatic substances depends not only on the species or strain of fungus but also on the cultural treatment, and much work has been done in an attempt to determine the effect of cultural conditions, such as composition of the medium, temperature, aeration, etc., on the stimulation or retardation of production. It is hoped that this will be published later; at present we wish to mention the significance of the composition of the culture medium in connexion with the strains of *Aspergillus* tested.

The positive and negative results given in the list are based on the size of zone produced on test. In order for this 'positive' or 'negative' assignment to have any absolute or relative value it must be a result which has been reasonably constant over a series of tests. Before trying the effect of different media it was necessary to estimate the degree of constancy of results to be expected from strains grown on different occasions on what was, as far as possible, the same medium. Five positive strains of *Aspergillus niger* were grown in two sets. In set A the five strains were grown on the same occasion, for the same time, on the same medium and were all tested together. In set B though the five strains were grown on the same medium for the same time, they were grown on different occasions and of course tested at different times, often by different assistants. The results are shown in the following table. The figures represent the total diameter of the area

Constancy of five strains of Aspergillus niger *under different conditions*

	Diameter of area of inhibition in mm.											
	A						B					
Lister no.	1	2	1	2	1	2	1	2	1	2	1	2
799	22	23	22	20	20	18	22	24	16	25	20	21
1161	19	19	20	20	20	20	19	21	16	22	18	20
1214	19	18	20	18	20	18	19	18	20	17	19	19
2389	19	22	18	17	22	21	22	20	15	21	19	23
2390	26	26	24	26	25	25	22	22	23	25	22	23

of inhibition in mm., and as the hole in the agar is always 11 mm. the actual width of the zone can be deduced. The first vertical column in each pair shows the result against *Bacterium coli* and the second the result against *Staphylococcus aureus*. *Pseudomonas pyocyanea* was not used in this experiment.

The table shows that the correspondence between the duplicate sets under A is very close and, even in the different sets under B, the variation is not experimentally significant. It seems, therefore, that, under similar experimental conditions, any given strain can be depended upon to give approximately the same result and there is justification for stating it to be positive or negative.

In order to find out the most suitable media for species of *Aspergillus* in general, certain species, chosen at random, were grown on twelve different media, six 'natural' and six 'synthetic'. The media were: malt, corn-steep, oatmeal, nutrient dextrose broth, carrot, potato dextrose, Leonian's, Richards', Crainsky's, Kauffmann's, ammonium nitrate sucrose, and modified Czapek Dox. It was found that certain species/strains produced positive results on almost all the media while some were negative on all media. Generally there was a marked preference for certain media, and, the positive fungi varied greatly in the degree of positive reaction according to the medium used. The three media on which the best positive results were obtained were: *Malt:* Kepler's malt extract 20 g. in 1000 ml. distilled water. *Potato dextrose:* potato liquor, made by steaming 200 g. diced potato for one hour and decanting off when cool, 1000 ml., dextrose 10 g. *Modified Czapek Dox:* dextrose 40 g., sodium nitrate 3 g., di-potassium phosphate 1 g., potassium chloride 0·5 g., magnesium sulphate 0·5 g., ferrous sulphate 0·01 g. and water 1000 ml. Though these media seem to be very favourable for inducing the production of bacteriostatic substances by the species of *Aspergillus* it does not follow that they are the best. They are to some extent 'ready made' and work which is now being done seems to indicate that more suitable media can be 'built up' to suit the requirements of individual fungi.

Conclusions

During this work we have been increasingly impressed with the importance of regarding every isolation as an individual fungus whose physiological potentialities are probably quite distinct from other isolations/strains of the same species. This is true not only of the species of *Aspergillus*, for the concentration of crude 'claviformin' varied greatly in relation to the different strains of *Penicillium claviforme* which were used. We have also found definite strain variation from strongly positive to negative in the larger basidiomycetes which are being investigated. As the medium on which the fungus is grown in the laboratory is responsible for so much variation in result it may well be that the substratum of the natural environment is also a factor in determining the subsequent reactions of the strain when isolated and grown in culture. Though direct evidence is lacking we incline strongly to this view.

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SOME OBSERVATIONS ON POWDERY MILDEWS

By W. A. R. DILLON WESTON, M.A., Ph.D. and R. ERIC TAYLOR, B.Sc., Ph.D., *School of Agriculture, Cambridge*

(With Plates X and XI)

Perennation of Apple Mildew (*Podosphaera leucotricha*) in the mycelial form was first referred to by Sorauer (1889), and by Galloway (1889) who considered the fungus to overwinter in the form of dormant mycelium in the leaf and flower buds. Similar views were later expressed by Tubeuf (1910) and by Fisher (1918). This means of perennation was confirmed by Woodward (1927) who showed it to be the primary means of hibernation of the fungus. Oak Mildew (*Microsphaera Alni extensa*) was also shown to perennate in the bud by Woodward, Waldie and Steven (1929). There does not appear to be any recorded evidence that Hawthorn Mildew (*Podosphaera Oxyacanthae*) can perennate in this way, although Brooks (1928) states that the life history is essentially the same as in *P. leucotricha*.

Brooks (1928), describing the life history of *Sphaerotheca mors-uvae*, the fungus causing American Gooseberry Mildew, states that 'Perithecia fall to the ground with the diseased berries, and from the autumn onward they fall also from the persistent mycelium on the twigs. Infection in the spring occurs mostly from ascospores liberated from perithecia on the surface of the soil.' Although infection undoubtedly occurs in this way it is not unlikely that in some seasons the fungus may overwinter in the form of dormant mycelium in the leaf and flower buds. Massee (1910) remarks that 'In many instances when a shoot appears to be perfectly free from disease a careful examination reveals the presence of minute portions of mycelium located between the buds and the shoot, and I suspect that this mycelium lurking in the axils of the buds plays the part of resting mycelium, and gives origin to the disease the following season, but I have no direct evidence on this point.' In an extensive survey of subsequent literature no confirmation of this hypothesis has been found. Rose Mildew (*S. pannosa*) also usually appears first on young leaves and shoots, and Theobald and Ramsbottom (1925) state that 'owing to the fact that in gardens the sexual stage is rarely present, an overwintering mycelium has frequently been postulated. There is, however, no convincing evidence for this.' Yarwood (1939) states, however, that on peach, *S. pannosa* can perennate in diseased buds which show systemic infection on emergence in spring.

In an old Cambridge country garden some of these diseases have been kept under observation for many years, and it has been noted that, when hawthorn hedges have been neglected and left untrimmed, mildew, *Podosphaera Oxyacanthae*, appears *early* in the season on young leaf or flower shoots and these are evenly mildewed all over and similar in their general appearance to apple shoots affected with *P. leucotricha* (Pl. X, fig. 1; Pl. XI, fig. 2). When these hedges are clipped in the autumn, however, mildew

in the following year is usually negligible and only isolated mildewed shoots are observed. The rambler roses in this garden suffer severely from *Sphaerotheca pannosa*, particularly where they are growing in the shade of trees, and the first appearance of it in the spring is usually confined to the newly formed young shoots which arise from old stems, and these become evenly mildewed all over (Pl. X, fig. 2). The bush trees, however, suffer but slightly and mildew appears later and then first on isolated leaves. These bushes are carefully pruned but the ramblers receive much less attention and many old stems are usually left. Although heavily overshaded, the gooseberry bushes are seldom affected with American Gooseberry Mildew, and in the past twelve years only traces have been noted. They are pruned annually but receive no spray treatment. In 1943, however, pruning was not carried out, and in the second week of April 1944 four young shoots were observed to be mildewed all over (Pl. XI, fig. 1), but the remainder of this bush and its neighbours were clean, or to the unaided eye appeared so. The disease spread rapidly, and a month later the berries on this and neighbouring bushes were very severely mildewed.

As the above observations afford circumstantial evidence that the diseases here noted may be able to perennate in the bud, it is suggested that a thorough study might usefully be made to confirm or disprove this view.

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EXPLANATION OF PLATES

Plate X

Fig. 1. Hawthorn shoots bearing a spur severely affected with mildew (*Podosphaera Oxyacanthae*).
Fig. 2. Rose spur severely affected with mildew (*Sphaerotheca pannosa*).

Plate XI

Fig. 1. American Gooseberry Mildew (*Sphaerotheca mors-uvae*) on a young terminal shoot of gooseberry.
Fig. 2. Mildew (*Podosphaera leucotricha*) on a young apple shoot.

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Fig. 2

Fig. 1

Fig. 2

Fig. 1

DEVELOPMENTAL STUDIES IN THE FUNGI

I. THE FOOT-CELL IN *ASPERGILLUS CLAVATUS* DESM.

By RICHARD KLEIN

(With 19 Text-figures)

The conidiophore in *Aspergillus* is generally described as consisting of three parts, i.e. the foot-cell, stalk and spore-head. Descriptions are always mainly concerned with the formation and development of the stalk and spore-head, and this is quite understandable, as these two parts, rising above the surface of the culture medium, are conspicuous, whereas the foot-cells, which are developed on or below the surface, are not visible to the naked eye, and to see them under the microscope it is often necessary to dissect the mycelium and to separate the hyphae which contain them. This is a tedious job and usually results in the breaking off of the foot-cell, either from the stalk or from the adjacent mycelial cells. This is even more true when the fungi are grown on solid media, when both direct observation and the preparation of slides are specially difficult. These circumstances probably explain why the descriptions throughout the mycological literature read as follows:

'Conidiophores or fertile hyphae arise by transformation of single hyphal cells into thick-walled and often characteristically shaped foot-cells from which the fertile stalks arise as perpendicular branches...' (Marshall (1921), p. 54).

'The first step towards conidium formation in this group is the differentiation of certain cells (the foot-cells, fig. 4) in the mycelium for reproductive purposes. These cells become larger, thick-walled, and each usually bears a single conidiophore as a branch, perpendicular to the long axis of the cell and about midway between the ends of the cell' (Thom & Church, 1926, p. 13).

'...fertile branches (stalks) arising from and more or less perpendicular to specialized, thick-walled, enlarged mycelial cells (the foot-cells),...' (Smith, 1942, p. 96).

'The unbranched conidiophore arises from an enlarged cell of the vegetative mycelium, the foot-cell, and terminates in a swollen portion, the vesicle' (Henrici, 1930, p. 97).

Similar descriptions are given by Fraser and Chambers (1907) and by Neill (1939).

De Bary (1887) is concerned only with the formation of the spores, and his drawing of the conidiophore of *Aspergillus glaucus* (on p. 203 of his account), shows no differentiation between the septate lowest part of the stalk and the hyphae from which it arises. In his extensive monograph, Wehmer (1901) does not even mention the foot-cell, but in contrast with the descriptions quoted above, the conidiophore is, according to Wehmer, a hypha rising vertically either as a lateral outgrowth or as the tip of the

hypha itself (Wehmer, 1901, pp. 36–7). In Lafar's *Handbuch der Technischen Mykologie* (1907), where *Aspergillus* is described by Wehmer, nothing is said of the foot-cell.

Thus authors have dealt with the foot-cell, if they have dealt with it at all, in but a few lines, while the stalk and the spore-head are fully described. It is rather surprising that so inadequate a statement is repeated throughout the whole of the mycological literature; apparently no thorough attempt has been made to follow up the development of the foot-cell. When the foot-cell is figured, it is nearly always shown isolated from the hypha, or else the neighbouring parts of the hypha are indicated only by two thin, parallel lines (Wehmer, 1895, 1901; Sartory & Sydow, 1913; Dale, 1914; Zikes, 1924; Thom & Church, 1926; Henrici, 1930; and many others). These figures give the impression that all the other parts of the hypha are of uniform diameter and do not differ from the rest of the mycelium.

If these descriptions are correct, then the naming of the basal part of the conidiophore as the foot-'cell' is not justified, since it does not form a separate cell but is merely a part of the conidiophore which, in most species, is not, or only inconspicuously, septate. In the English edition of Lafar's *Handbuch* (1910) the conidiophore is described 'as a rule, consisting of an unbranched, unicellular hypha'. Therefore the three parts, foot-'cell', stalk and vesicle, are always portions of the same one cell, though they change their relative sizes as development goes on. It would be better to speak of the 'foot-part' rather than of the 'foot-cell'. This is valid when the development occurs in accordance with the quotations which have been given above, but it is certain that development does not always proceed in that way, and it is doubtful which manner of development is the more frequent, for, so far, very little attention has been directed to the matter. One investigation which seems to have been completely overlooked, for it is never mentioned in any paper or text-book, is the work of Čelakovský (1912) on *Aspergillus clavatus* and *A. niger*; the former species is treated in more detail, and a translation of the relevant paragraph follows:

'When considering the formation on nutrient agar of the thick, club-shaped conidiophores, it can be seen that the stalks arise from certain swollen cells of the hyphae. These peculiar foot-cells occur also in other species of *Aspergillus*, e.g. in *A. niger* v. Tiegh. When a plentiful supply of nutrients is present in the substratum, the conidiophores arise close to it, and from aerial hyphae; then the foot-cells are not very obvious. On poorer media on the other hand, or when the nutrient substances have been partly used up (in older parts of the mycelium), the foot-cells are formed in submerged hyphae, and here it is easily possible to follow their development. One may see also how the cells adjacent to the foot-cell swell more or less, and how then from the foot-cell a branch arises which bends obliquely or vertically upwards and is transformed into the club-shaped conidiophore. With respect to the more lanky conidiophores, they originate, so far as I could observe, only on aerial hyphae, or more strictly speaking by the transformation of aerial hyphae, and they lack foot-cells. In the submerged mycelium, during the time when foot-cells are being

formed, fusions frequently occur between neighbouring mycelial branches, as well as the linking-up of pairs of cells which lie one behind the other in the same hypha, particularly in the neighbourhood of the foot-cells.'

Unfortunately, Čelakovský's drawings are little more than diagrams, and neither a foot-cell nor the adjacent mycelial cells are drawn properly.

During a joint investigation on an antibacterial substance from *A. clavatus* (Bergel, Morrison, Moss, Klein, Rinderknecht & Ward, 1943), I had a unique opportunity to investigate a very large number of cultures on a variety of liquid media. The purpose of this communication is to describe the development of the foot-cell in *A. clavatus*, as it was observed in these cultures. The fungus was grown in various modifications of the Czapek-Dox solution, in Sabouraud's solution with either maltose or dextrose, and on media with a source of carbon other than a sugar; an account of the influence of these media on the morphology of the fungus will be given in a later paper. Except for insignificant differences in size, the foot-cell developed in the same way in all the cultures. The description and the figures which follow are based on observations on material grown on a variety of media, and they show the manner of development typical on all the media used in the investigation. It is obvious that changes in individual conidiophores could not be followed up, for the preparation of the slides inevitably stopped development; but the numerous observations give a clear idea of the successive stages of development.

Fig. 1. *Aspergillus clavatus*. The explanation of this, and of subsequent figures, will be found in the text. All figures, except Fig. 19, are from camera-lucida drawings. A scale is appended to each figure.

The first stage that can be recognized shows the young conidiophore at the end of a hypha, arising from a club-shaped cell. This cell, as will be shown, is the proper foot-cell, and it is as yet separated from the stalk by a cross-wall. The other cells of the hypha also are club-shaped, with the swollen end of each directed towards the conidiophore (Fig. 1). These hyphae are very distinct from the rest, which are of uniform and of much smaller diameter, but the entanglement of the mycelium makes it impossible to follow these hyphae to their place of origin. Sometimes, hyphae consisting of club-shaped cells without a conidiophore may be found, but, for

a reason to be given later, it is more likely here that the conidiophore has been broken off than that it has not yet developed. It is of interest that Wehmer (1895) gives a drawing of similar swollen cells in *A. Oryzae* grown on a solution containing sugar, but he does not bring them into relation with the conidiophores.

As the position of these conidiophore-bearing hyphae—which in the sequel will be called *conidiophoral* hyphae—cannot be determined by direct observations on the culture, and as the position must be upset during the preparation of a slide, it is difficult to decide if, in the undisturbed culture, they are substratal or aerial hyphae. But, as in a later stage the conidiophores are perpendicular to them, the conidiophoral hyphae must run parallel to the surface of the medium, either on it or a little underneath. This and other questions, and especially whether the enlargement of a mycelial cell occurs before the stalk develops, or only after it has reached a certain size, can be studied only by direct observation. A method of doing this is being worked out, and, if it proves successful, it will be described at a later time.

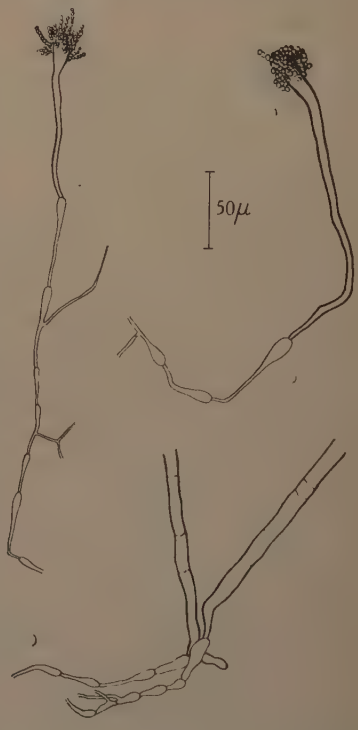


Fig. 2.

In the first stage, the cells of the conidiophoral hypha next to the conidiophore, are unbranched, but older cells, lying farther back in the hypha, are branched (Fig. 2). Usually one hypha, of small and uniform diameter, and so resembling the bulk of the mycelium, develops from each cell at a distance of about one-third the total length from the club-shaped end. This hypha contains a septum close to its point of origin, and, as it lengthens, the hypha becomes septate, and branches more and more as it ages. The whole arrangement suggests that these thin hyphae connect the conidiophoral hypha with the medium, into which they grow, and from which they take nutritive material; they will therefore be called *feeding* hyphae.

In the second stage a feeding hypha may be seen growing out from the foot-cell, i.e. from the club-shaped cell adjacent to the conidiophore (Fig. 3). Sometimes (Fig. 4) the tip of the feeding hypha can be seen; this shows it to be a branch from the conidiophoral hypha and not the product of a fusion between two separate hyphae. This is of importance, for when the feeding hypha of the last club-shaped hypha is too long for its tip to be found, or when that tip is covered and obscured by other parts of the mycelium, the impression can be wrongly gained that a fusion of two hyphae has taken place. It would be rather tempting to consider the

conidiophoral hyphae as female or as hermaphrodite, and the thin hyphae as males (or as + and −), thus providing a sexual basis which could easily be brought into agreement with the 'dual phenomenon' of the C and M types described by Hansen (1938) and by Hansen & Snyder (1943). Although this is not so, and although the conidiophore is not the product of a fusion, there might still be some relation to the 'dual phenomenon'. If it can be shown that the M type is lacking in the conidiophoral hyphae or that the latter do not develop into conidiophores for reasons as yet unknown, the hypothesis of the dual phenomenon might be further supported. It is hoped to investigate this matter, for the strain of *A. clavatus* used in this work splits under certain conditions into a C and an M type; an investigation into the possibility of nuclear changes at this stage is also necessary.

The third stage shows the foot-cell changing in shape. The part where the feeding hypha arises grows into a prolongation of the foot-cell which thus becomes crescentic (Fig. 5). This growth turns the conidiophore into a position perpendicular to the conidiophoral hypha. In this stage the conidiophore is still separated from the foot-cell by a transverse septum, but the wall of the foot-cell sometimes thickens as that of the conidiophore thickens (Fig. 6).

In the fourth and last stage the septum disappears and the foot-cell and the conidiophore become continuous (Fig. 7). The complete conidiophore, consisting of a basal part developed from the foot-cell, the stalk, and the spore-head, is now present. It seems that during the third stage the growth of the

Figs. 3–6.

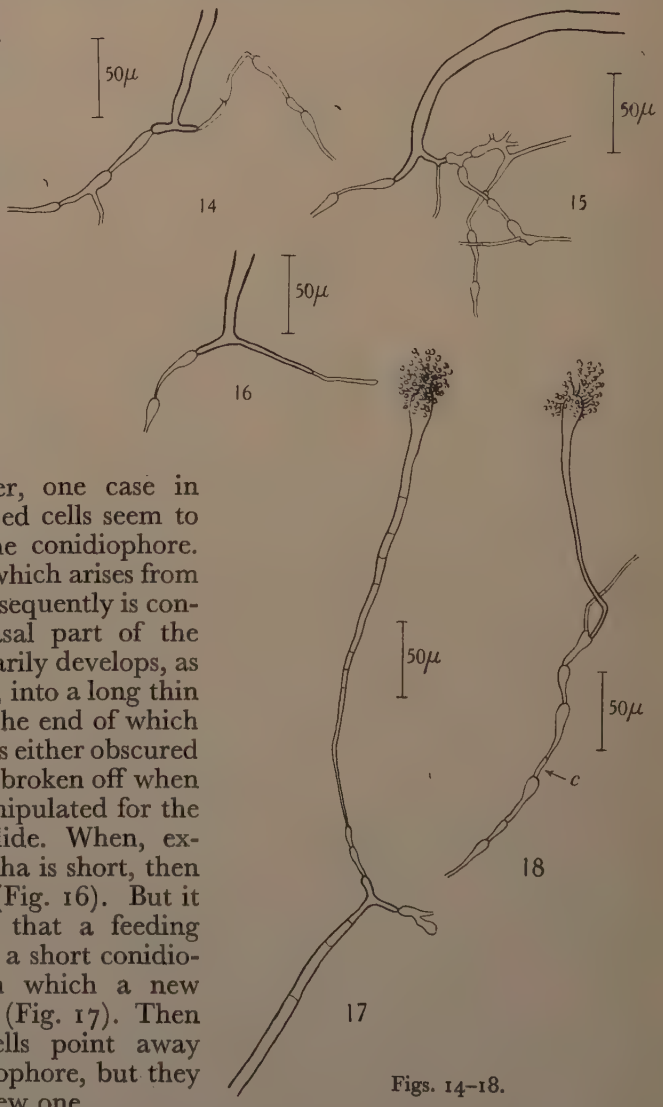
foot-cell may be irregular, and, accordingly, we often find that stalk arising at or near the end of the foot-cell and not from its middle (Fig. 8).

It is known that the basal parts of old conidiophores have very often more than two branches, and, as these branches are often curved, the basal part of the conidiophore then looks like a claw. An idea of how this develops can be gained from Figs. 9–12. Fig. 9 shows both ends of the basal part curved, but it is impossible to decide if the foot-cell was already curved before the septum between it and the stalk disappeared, or if the curvature developed later. In Fig. 10, the foot-cell still has a septum between it and the stalk, and it bears an outgrowth. A similar hump can be seen in Fig. 11, and here the septum has disappeared. In both, the outgrowth looks like the beginning of another branch from the basal part. Fig. 12 is of special interest. Here, two feeding hyphae arise from the foot-cell and the future claw-shape is already indicated. This figure also explains how, in old conidiophores, each end of the basal part is connected with a hypha.

Other questions suggested by these observations are, How is it that the cells of the conidiophoral hyphae are club-shaped? and How is it that their swollen ends are turned in the same direction? Until it has been found possible to take direct observations on the growing fungus, the position of the conidiophoral hypha in growth can only be conjectured. But, as it is known that the undisturbed growing mycelium is of circular form, and as the conidiophores crop up in rings, with sterile mycelium in between, thus creating dense zones alternating with loose zones, and resembling the fairy rings formed by toadstools, it seems obvious that the conidiophoral hyphae run in a radiate direction with the swollen ends directed towards the periphery. In the same way as the formation of the conidiophores is connected with the progressive exhaustion of the medium, and this not only on a solid medium but on an undisturbed liquid medium, so the rhythm of the formation of the conidiophoral hyphae might depend upon this exhaustion. As already mentioned, club-shaped cells occur in other species of *Aspergillus*, but in *A. clavatus* there may be a special tendency in this direction, causing finally the club-shaped vesicle. The plastic material for the formation of the conidiophores is formed in and transported through the conidiophoral hyphae and maybe is in part stored in the club-shaped cells until it is used in the conidiophore. There may well be some special quality in this material which determines both the form of the cells of the conidiophoral hyphae and that of the spore-heads. In agreement with this assumption it is to be expected that all the hyphae leading away from the conidiophoral hyphae, i.e. the feeding hyphae, which either branch off directly from the cells of a conidiophoral hypha, or develop from foot-cells beyond the basal part of the conidiophore, will all be threads of uniform diameter; this is generally true (Figs. 2–12). There are, however, exceptions. Fig. 13 shows two conidiophoral hyphae which seem to bear feeding hyphae with club-shaped cells. Fig. 14 shows a conidiophore with what appear to be two conidiophoral hyphae, although there is a cylindrical cell on one side of the basal part; Fig. 15 resembles a combination of

Figs. 7–13.

Figs. 13 and 14. The cause of these irregularities may be found in internal disturbances of the plasmatic structure, or in external interferences which may easily happen in a liquid medium. The colonies do not arise from single spores and between them others begin to grow, upsetting the undisturbed development of the mycelia. An accidental shaking of the culture vessel might hasten the intermingling of the hyphae, whether they belong to the same or different colonies, and fusions and anastomoses might be possible. Be all this as it may, it is striking that the club-shaped ends always point towards the conidiophore.



Figs. 14–18.

There is, however, one case in which the club-shaped cells seem to point away from the conidiophore. The feeding hypha which arises from the foot-cell and subsequently is connected with the basal part of the conidiophore, ordinarily develops, as has been mentioned, into a long thin hypha (Figs. 7, 8), the end of which cannot be seen, as it is either obscured by the mycelium or broken off when the mycelium is manipulated for the preparation of a slide. When, exceptionally, this hypha is short, then its tip can be seen (Fig. 16). But it happens sometimes that a feeding hypha develops into a short conidiophoral hypha from which a new conidiophore arises (Fig. 17). Then the club-shaped cells point away from the old conidiophore, but they point towards the new one.

For completeness it should be mentioned that there are occasionally found in a conidiophoral hypha, odd cells which remain cylindrical and do not become club-shaped (Figs. 4 and 18, indicated by *c*). This seems to be unimportant, and is probably due to casual disturbance.

The conversion of the foot-cell into part of the conidiophore is shown

diagrammatically in Fig. 19, in the four typical stages which were always found in the cultures on liquid media. The club-like shape of the cells of the conidiophoral hyphae was less noticeable and constant in very old and large conidiophores. This might be because the conidiophoral hyphae had accomplished their task, and the club-shaped ends of the cells had become shrunken, whereas the feeding hyphae, especially the latest-formed ones, arising from the foot-cells, became thicker at this stage, as they still had work to do in transporting material from the medium to the conidiophores. When the conidiophores are very young and thin, the cells of the conidiophoral hypha are not club-shaped, or are but slightly so. It seems that the conidiophore is formed first, and that the swelling takes place later; therefore it is believed that when conidiophoral hyphae without conidiophores are found, the latter have been broken off.

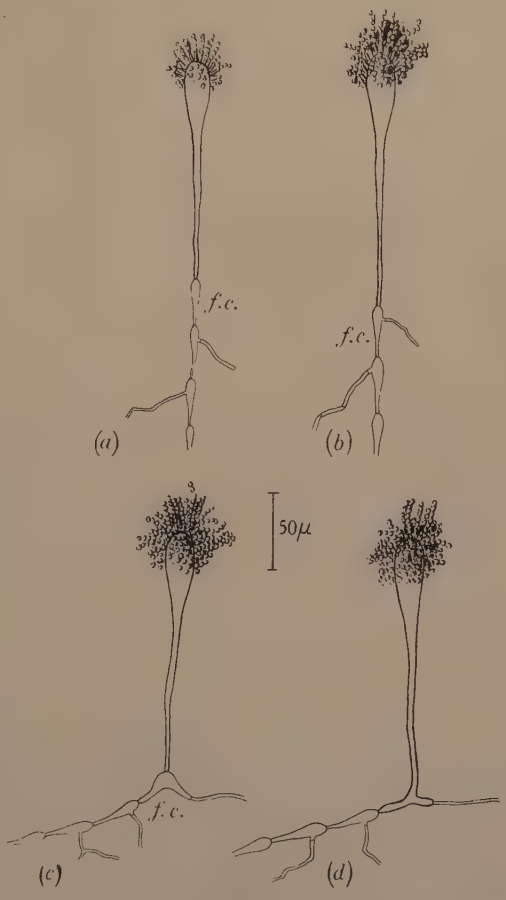


Fig. 19 *a–d*. Four diagrams to show successive stages in the development of the foot-cell (*f.c.*). In *d* the septum has disappeared, so that the lumen of the foot-cell is now continuous with that of the stalk.

Investigations of cultures on solid media, and of other species of *Aspergillus* will show if or no the occurrence of conidiophoral hyphae is general, but it will be difficult to follow development in detail, especially in those species which have long or brittle stalks; but it is also possible that there are other and very different methods of the development of the conidiophore, for there is as yet no evidence that the method described here is the only possible method. It is hoped that the abundant material which has been preserved from the cultures will make possible an investigation of the manner of formation of double foot-cells and of other complicated structures which are frequent in cultures.

SUMMARY

As part of an investigation into the formation of the conidiophore of *Aspergillus*, a detailed study has been made of *A. clavatus*. Sufficient stages have been found to allow of a reconstruction of the process in this species, but the results may not apply to all species of the genus.

From specialized conidiophoral hyphae, the conidiophore arises from the terminal cell, which itself becomes the foot-cell of the conidiophore. This foot-cell sends out one, or rarely two feeding hyphae and then alters in shape and in position in relation to the conidiophore. Finally, the septum between the foot-cell and the conidiophore disappears and the two become continuous; a diagram is given to illustrate this.

Mention is made of a possible connexion between the manner of formation of the conidiophore and the 'dual phenomenon', and the theoretical aspects of the formation of the conidiophore are discussed.

Some exceptional examples are described, and an attempt is made to explain them.

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CHLORAZOL BLACK E AS A STAIN FOR MYCOLOGICAL SPECIMENS

By F. D. ARMITAGE, A.R.P.S., F.R.M.S., F.L.S.

(With Plates XII and XIII)

Chlorazol black E is an acid dye which was introduced as a biological stain by Cannon (1937). Its uses are numerous and it can be successfully adopted by the mycologist for staining many of the common Hyphomycetales, giving a depth of staining which is particularly useful for specimens which have photomicrographically to be recorded.

The dye can be added to lacto-phenol mixtures, with or without picric acid, and in this form is useful for temporary mounts. Sufficient dye should be added to the lacto-phenol mixture to produce a dense black solution; this is given a thorough shaking and is allowed to stand for two or three days before it is filtered for use (1 g. of the dye will produce a saturated stain in 250 c.c. of lacto-phenol).

All moulds do not stain with equal intensity in a given time. Species of *Penicillium* and *Aspergillus* stain very rapidly—a matter of minutes—while others, such as *Thamnidium*, may take hours to acquire any coloration, so that an immediate result must not always be expected. Furthermore, the stain reacts more readily with young than with old material.

Specimens mounted in the lacto-phenol-dye mixture can be kept for a long time if the coverslips are cemented to the slide with the Brown Ringing Cement supplied by Flatters & Garnett of Manchester.

Permanent slides

As a saturated stain made up in 70 % ethyl alcohol—filtered before use—the dye can be used during the preparation of specimens which are permanently to be mounted and the following is a convenient schedule of procedure similar to one which has already appeared (Armitage, 1943).

Petri dishes containing a small volume of Czapek's agar are inoculated with the organism to be mounted and, when the colonies have grown to the required stage, the plate is very gradually flooded with 70 % alcohol. The specimens are left undisturbed in the alcohol for at least three hours and then a small volume of the dye in 70 % alcohol is added.

The staining is watched through a binocular dissecting microscope or a lens, and when it is considered that the organism is sufficiently dyed, the stain is carefully decanted away, being replaced by 70% alcohol in order to wash away excess dye. After washing, the specimens and the agar substratum are dehydrated prior to mounting in euparal* in the following manner:

(1) By means of a narrow-bladed scalpel or a dissecting needle with a knife edge, a portion of the agar on which the selected specimen has been

* Euparal is a mountant made up from camsal, sandarac, eucalyptol and paraldehyde. It is manufactured in this country according to Gilson's original formula by Flatters & Garnett Ltd.

growing is cut from the dish and is transferred carefully from the dehydrant, using a section lifter, to a slide on which a generous amount of euparal mountant has been centrally placed.

(2) A coverslip is now put over the specimen and the slide is set aside on a warm plate—this must not exceed a temperature of 50° C. or slides will be ruined—so that excess solvents will evaporate from the mountant. During this period the euparal slightly contracts and it has not been found necessary to apply any external weight to coverslips in order to flatten specimens.

Should an observer wish to mount a small colony without fixing a whole plate with alcohol, a similar schedule can be followed, but the colony chosen for mounting must be transferred, before fixing, to a small dish or watch glass for manipulation. If this is done it is important lightly to hold specimens down in the watch glass with the point of a dissecting needle, or seeker, while the reagents are applied, otherwise the specimens may float to the surface and it is then impossible to submerge it in the alcohols, dye, etc., without disturbing lightly attached spores.

Use of dioxan

Dioxan—diethylene dioxide—can be used as a dehydrating reagent after specimens have been fixed and stained in 70% alcohol and chlorazol black E. It does not appear greatly to distort the specimens, which can be mounted in the following gum-sandarac-camsal-dioxan mixture, details of which have already appeared (Armitage, 1939):

(1) 25 g. of gum sandarac are dissolved in excess of dioxan and the solution is filtered through glass wool until clear—the filtrate may have to be passed through the glass wool several times.

(2) The filtrate is evaporated to a thick syrup; the evaporation being carried out on an oil bath or a bath of Woods' metal heated till it flows readily. (If a water bath is used condensed steam may find its way into the syrup and ruin the mountant.)

(3) Prepare a solution of camsal: rub together in a mortar 3 g. of salol —sodium salicylate—with 2 g. of camphor, and the mixture will slowly liquify particularly if gently warmed.

(4) To every 20 c.c. of the syrup obtained at stage 2 of the procedure add 1 c.c. of camsal.

(5) The mounting medium should now be ready for use; if it is too thin, a further evaporation until it has the consistency of a normal mounting medium may be required before the mountant is stored in a well-capped balsam bottle.

Dioxan gives off a vapour which is a cumulative poison, it is important therefore to keep all vessels in which it is used covered as much as possible between the manipulative stages.

Conclusion

Experimental work with chlorazol black E is still going on. Its use as a cytological stain in mycology has yet to be explored, but it is found that the staining reaction is greatly increased if absolute *methyl alcohol* is used

Fig. 1

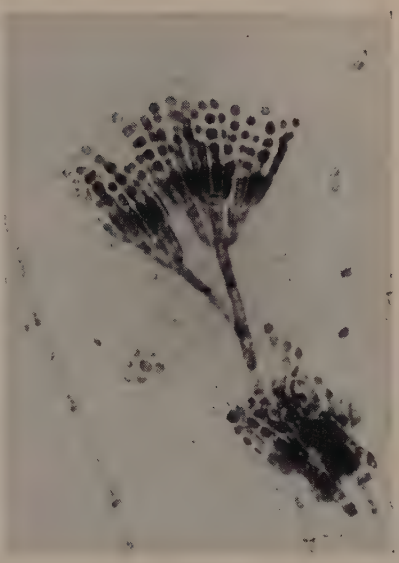

Fig. 2

Fig. 3

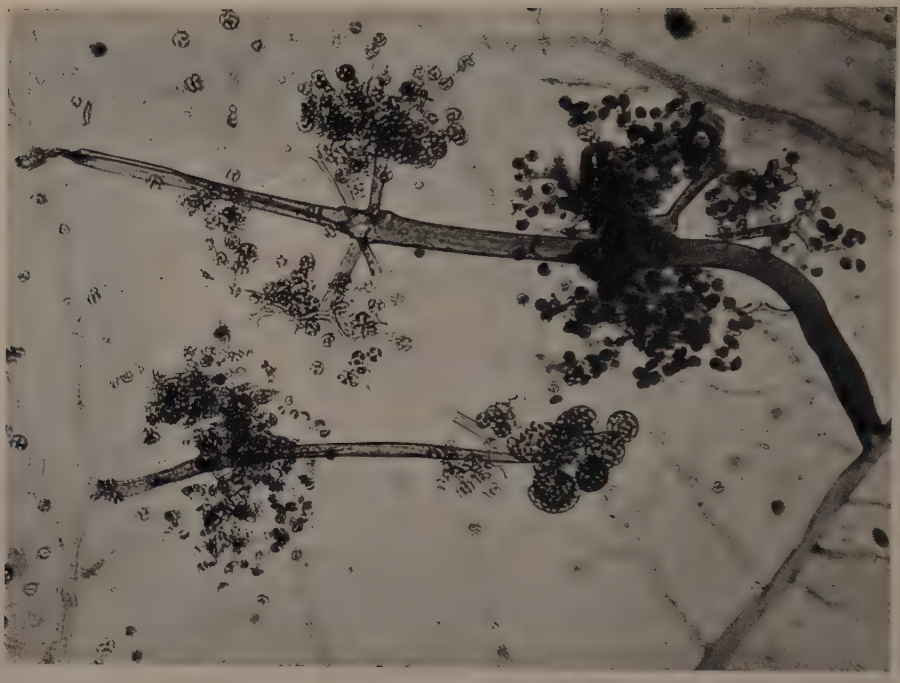

Fig. 5

Fig. 4

in place of the 70 % ethyl alcohol and as a stain in the former solvent it may prove to be of more universal use.

Finally, I wish to thank the Council and Director of Research of The Printing & Allied Trades Research Association for permission to publish this paper, and thanks are also due to Professor H. G. Cannon for advice during the experiments with the dye, and to G. Smith, Esq. for supplying a number of pure cultures.

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EXPLANATION OF PLATES

PLATE XII

Fig. 1. *Penicillium* sp. × 200. After 20 min. immersion in lacto-phenol-chlorazol black E mixture. Figs. 1 and 2 are reproduced through the courtesy of the Royal Microscopical Society.

Fig. 2. *Penicillium* sp. × 350. Stained chlorazol black E in 70 % ethyl alcohol and mounted in euparal.

Fig. 3. *Aspergillus* sp. × 130. Stained and mounted as described in euparal mountant.

PLATE XIII

Fig. 4. *Botrytis* sp. × 320. Stained and mounted as described in sandarac-camsal-dioxan mountant.

Fig. 5. *Thamnidium* sp. × 200. Stained and mounted as described in euparal.

A *PYTHIUM* ROT OF CUCUMBERS

By F. T. BROOKS, *Botany School, Cambridge*

Cucumber fruits (variety Telegraph) have been completely rotted in a heated glasshouse at Cambridge by a species of *Pythium* both in 1943 and 1944. The cucumbers were grown in boxes of soil from which the shoots trailed over the staging. The fruits lay on the staging in contrast to the pendant position usual in commercial cultivation. The staging was covered with granite chips which were intermixed with a good deal of soil owing to long usage of the glasshouse. Both young and mature fruits became soft-rotted, and associated with the rot was a superficial white, non-septate mycelium. In partly affected fruits it could sometimes be seen that infection had occurred at the tip, perhaps through the remains of the flower. Contamination probably occurred from the soil intermixed with the granite chips; there was a good deal of splashing of water over the staging in order to maintain a humid atmosphere.

The diseased fruits were soft and permeated with a dense, much branched, non-septate mycelium. When they were cut off and kept in a saturated atmosphere a profuse white mycelium, like cotton-wool, grew out to a distance of about 1·5 cm. from the surface. This growth was accompanied by a somewhat pleasant odour, quite unlike that associated with bacterial disintegration of vegetable tissues. The symptoms agreed closely with those described by Drechsler (1925) for the rot of cucumbers in transport caused by *Pythium aphanidermatum* and known as 'cottony leak', but, as will be seen later, this was not the species here.

Pure cultures were readily established from the aerial mycelium and from the interior of the diseased fruits. Preliminary experiments showed that the fungus was intensely pathogenic to cucumber fruits, causing a complete soft rot within 72 hours. The cultures were compared with *Pythium ultimum* Trow, isolated from a wilted *Delphinium* some years ago and identified by Dr Drechsler, and with *P. aphanidermatum* (Edson) Fitzpatrick kindly sent me by Mr C. J. Hickman who has described (1944) a disease of cucumber stems near soil level caused by it. The fungus isolated from cucumber fruits agreed entirely with *P. ultimum* except that all attempts to induce it to form sexual organs completely failed. Abundant conidia (the sporangia of some authors) were produced on a variety of media, but, as with *P. ultimum*, these never gave rise to zoospores. With *P. ultimum* sexual organs are readily formed on maize-extract agar, in cabbage decoction, and in water to which fragments of hemp seeds have been added. In the monograph by Middleton (1943) of the genus *Pythium*, a few species are described in which sexual reproduction has not yet been observed, but their characters are quite different from those of the fungus here under consideration. In pathogenicity this isolate from cucumber is identical with *P. ultimum* for it causes a similar soft rot of potato and carrot

tissues. It seems likely, therefore, that the fungus causing the rot of cucumber fruits is a strain of *P. ultimum* which has lost the capacity to produce sexual organs. This belief is strengthened by the investigations of Tompkins *et al.* (1939) on a soft rot of pumpkin and watermelon fruits caused by *P. ultimum*, who found that some of their isolates were entirely asexual.

Inoculations of mature cucumber fruits were carried out simultaneously with *P. ultimum*, the fungus isolated from cucumbers, and with *P. aphanidermatum*. The cucumbers were well washed and then surface sterilized with alcohol. Mycelium of the three fungi was inserted in shallow wounds or applied to the surface without wounding, the fruits being then kept in a saturated atmosphere. Invariably within 24 hours there was a vigorous growth of mycelium, accompanied by a softening of the contiguous tissues. Within 72 hours the cucumbers were completely rotted and enveloped in a dense mass of white mycelium, like cotton wool, extending at least 1·5 cm. from the surface. No differences were observable between the three fungi as regards the amount of aerial mycelium or the rate of rotting; they all emitted a pleasant odour when growing vigorously on the cucumbers. At a later stage the aerial mycelium collapsed on to the surface and fluid began to exude from the rotten fruits. In the mycelium on the surface of the cucumbers *P. aphanidermatum* showed abundant sexual organs and oospores, *P. ultimum* conidia as well, but the cucumber isolate showed only conidia. The symptoms of attack agree precisely with those described by Drechsler (1925) for the 'cottony-leak' of cucumbers. In comparable inoculation experiments with other species of *Pythium*, chiefly strains of *P. debaryanum* Hesse and perhaps strains of *P. ultimum* for at that time the two species had not been clearly differentiated, Drechsler found that *P. aphanidermatum* gave rise to a much more profuse mycelium on the surface of the cucumber than did the other species. In my own experiments, however, strains of *P. ultimum* have behaved indistinguishably from *P. aphanidermatum* when inoculated into cucumber fruits.

It is not surprising to find that *P. ultimum* may be actively pathogenic to cucumbers for the ability of this fungus to cause a soft rot of other vegetable tissues, notably the 'leak' disease or 'watery wound rot' of potato tubers, is well known. Although *P. ultimum* is often a wound parasite it can clearly attack cucumbers without the assistance of wounds.

Summary

A rot of cucumber fruits caused by a species of *Pythium*, probably a strain of *P. ultimum*, is described, the symptoms being precisely similar to those described by Drechsler (1925) for 'cottony leak' caused by *P. aphanidermatum*.

The fungus produces no sexual organs, but is otherwise identical in morphology and pathogenicity with *P. ultimum*.

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CEYLON FUNGI, NEW AND OLD

By T. PETCH

The new fungi enumerated in the present paper, with one exception, were collected during my residence at Nuwara Eliya, Ceylon, during 1927–8. Nuwara Eliya is situated at an elevation of 6200 ft., is subject to the rains of both monsoons, and has a high humidity with a low night temperature and occasional frosts. Probably in consequence, its fungus flora differs considerably from that of districts at lower elevations, even from that of Hakgala, six miles distant and 600 ft. lower, which receives the rains of only one monsoon and is not subject to frosts, and I regret that it was not possible to make a detailed investigation of it. I have added notes on other Ceylon species which may be of interest.

Basidiomycetes

Armillaria mellea (Vahl) Fr.

I found this on a stump in the jungle at Nuwara Eliya in 1928, and I now agree that *Armillaria fuscipes* Petch is the same species. It appears to be an 'up-country' species, and the white colour of the type of the latter may have been due to its unnatural growth at the lower elevation of Peradeniya (1560 ft.), where it was developed in a plant pot under a bell glass on an *Acacia* stump from an up-country district.

Arrhenia minuta Petch, n.sp. (Pleuropus).

White, subdiaphanous, fleshy not gelatinous. Stalk becoming brown or blackish at the base, slightly attenuated upwards, 2·5 mm. high, 0·25 mm. diameter below, glabrous; pileus attached laterally to the stalk, oval in outline, convex, thin, about 1·5 × 1 mm., with either a single median gill, or a vein which may be shortly forked at the outer end, extending from the stalk to the margin on the lower surface; surface of the pileus composed of cells about 12–16μ diameter, spinulose at their outer end, a few projecting as short, spinulose hairs about 16μ long. On dead leaves of *Amomum*, no. 4547, Hakgala, May 1912.

Alba, subdiaphana, carnosa; stipite basi fuscescenti, 2·5 mm. alt., infra 0·25 mm. diam., glabro; pileo laterali, ovali, convexo, membranaceo, circa 1·5 × 1 mm.; aut lamella unica aut vena interdum ad marginem breviter furcata.

It is hoped to publish a revision of Ceylon *Marasmii*. Meanwhile, the following synonymy may be of service:

Mycena auroricolor Petch, nom. nov.; *Marasmius Wynniae* var. *auroricolor* B. & Br., Fungi of Ceylon, no. 353.

Marasmius actinophorus B. & Br., F. of C., no. 385; *M. coronatus* Petch, *Ann. Perad.* VI, 58.

Marasmius Campanella Holtermann, *Myk. Unters.* (1898), p. 105; '*Cantharellus capensis*' (in part), F. of C., no. 350. *M. rufescens* B. & Br., F. of C., no. 394, and *Xerotus tener* B. & Br., F. of C., no. 426, refer to the rufous form of this species, and the former may be used as a varietal name.

Marasmius concolor B. & C. The Ceylon specimens attributed to this species are *Crepidotus melleus* (B. & Br.) Petch (*Aschersonia mellea* B. & Br.).

Marasmius confertus B. & Br., F. of C., no. 352; *M. chondripes* B. & Br., F. of C., no. 364; *M. hemibaphus* B. & Br., F. of C., no. 379.

Marasmius congregatus Mont., Guy., no. 307; *Cantharellus elegans* B. & Br., F. of C., no. 346; *M. pellucidus* B. & Br., F. of C., no. 359.

Marasmius fulviceps Berk., *Hooker's Lond. Jour.* 1847, p. 490; *M. nummularius* B. & Br., F. of C., no. 351.

Marasmius leucophaeus (B. & Br.) Petch, comb. nov.; *A.* (*Collybia*) *leucophaeus* B. & Br., F. of C., no. 113; *M. cornicolor* B. & Br., F. of C., no. 361.

Marasmius Leveillianus (Berk.) Pat., *Bull. Soc. myc. France*, xxxiii (1917), 55; *Heliomyces Leveillianus* Berk., *Decades of Fungi*, no. 158; *M. umbraculum* B. & Br., F. of C., no. 365.

Marasmius multijugus (B. & Br.) Petch, comb. nov.; *A.* (*Collybia*) *multijugus* B. & Br., F. of C., no. 100.

Marasmius mutabilis B. & Br., F. of C., no. 367; *M. eximius* B. & Br., F. of C., no. 371.

Marasmius nephelodes (B. & Br.) Petch, *Ann. Perad.* iv, 403; *A.* (*Collybia*) *nephelodes* B. & Br., F. of C., no. 105; *M. ochraceus* B. & Br., F. of C., no. 355; '*Hygrophorus obrusseus*', in Berk., *Hooker's Lond. Jour.* vi.

Marasmius pallidorubens (B. & Br.) Petch, comb. nov.; *A.* (*Mycena*) *pallidorubens* B. & Br., F. of C., no. 119.

Marasmius proletarius B. & C. The Ceylon specimens and painting referred to this species are young specimens of *M. coniatus* B. & Br.

Marasmius proximus B. & Br., F. of C., no. 368; *M. obscuratus* B. & Br., F. of C., no. 370, not of Petch in *Ann. Perad.* vi, 56.

Marasmius rhyssophyllus Mont. The Ceylon specimens attributed to this species are *M. crispatus* B. & Br.

Marasmius rigidichorda Petch, nom. nov.; *M. obscuratus* Petch non B. & Br. in *Ann. Perad.* vi, 56.

Marasmius sulcipes Berk., Decades of Fungi, no. 156. This appears to be a *Naucoria*.

Corticium hypophyllum Petch, n.sp.

Forming small, thin, white, powdery or compact patches on the under side of living leaves, without repent mycelium elsewhere or a hyaline film beneath the patch. Basal hyphae 3–4 μ diameter, with prominent clamp connections; erect branches dividing dichotomously, terminating in a group of four-spored, ovoid or subquadrangular basidia, 7–10 × 4–5 μ, with short conical sterigmata, 1–1·5 μ high, not attenuated; spores oval, inequilateral, or broadly cymbiform, 3·5–5 × 2·5–3 μ. On the under side of living

leaves of *Lasianthus*, Nuwara Eliya, 3 July 1927. Not a Thread Blight, and apparently not parasitic.

Parvum, album, tenue, circumscriptum, farinosum interdum compactum; basidiis ovoideis vel subquadrangularibus, tetrasporis, 7–10 × 4–5 μ, sterigmatibus brevibus, conicis, non attenuatis, 1–1·5 μ alt.; sporis ovalibus, inaequilateralibus, vel late cymbiformibus, 3·5–5 × 2·5–3 μ; hyphis subjacentibus, 3–4 μ diam., hyphis erectis dichotome ramosis.

Hymenochaete vagans Petch, n.sp.

Mycelium rufous, extending in strigose strands and sheets over dead twigs, etc., on the jungle floor and ascending the stems of living plants up to a height of about a foot, but not injuring them. Hymenium on the under side of living leaves, forming a very thin, continuous, red-brown film which curls off the leaf on drying and shows a glabrous under surface. Basidia four-spored, clavate, 14 × 5 μ (measuring down to the basal horizontal mycelium), one-septate, constricted at the septum, the upper segment cylindrical, 8 μ long; sterigmata short, conical, about 1 μ long; setae straight, 60–80 μ long, 6–8 μ diameter below, tapering to the acute tip, usually not septate, wall 1·5 μ thick, yellow-brown; spores hyaline, oblong-oval, 5–6 × 3·5 μ. Nuwara Eliya, 19 August 1927.

Mycelio rufo, in chordis strigosis et linteis supra quisquilias plantarum currenti, caules fruticum vigentium conscendenti et hymenium hypophyllum producenti; resupinata, effusa, rufo-brunnea, continua, tenuissima, adnata, separabilis, infra glabra; basidiis tetrasporis, clavatis, 14 × 5 μ, uniseptatis, segmento terminali cylindraceo, 8 μ longo; sterigmatibus brevibus, conicis, ca. 1 μ longis; sporis hyalinis, oblongo-ovalibus, 5–6 × 3·5 μ; setis rectis, 60–80 μ alt., infra 6–8 μ diam., ad apicem acutum attenuatis, saepius aseptatis, pariete 1·5 μ crass., flavo-brunneis.

Septobasidium

The following additions have been made to the species of *Septobasidium* known from Thwaites's collections. I am indebted to Dr J. N. Couch for most of the determinations; and descriptions and illustrations of these and the previously known Ceylon species will be found in his *Monograph of the Genus Septobasidium* (1938). The number of species now known from Ceylon (including *Helicobasidium*) is twenty-two.

Septobasidium Boedijnii Couch, 1938, p. 198.

Common at Nuwara Eliya and Hakgala on *Lasianthus*, also found on *Hedyotis*, January 1914, etc.

Septobasidium bogoriense Pat.

On *Hemichionaspis aspidistrae* on an undetermined plant, Peradeniya, 1909; on *Citrus*, Peradeniya, September 1921; on *Erythrina lithosperma*, Millakande, April 1928.

Septobasidium Curtisii (Berk. & Desm.) Boed. & Stein.

On bamboo, Nuwara Eliya, September 1926.

Septobasidium hakgalanum Couch & Petch, in Couch, 1938, p. 142.

On stems of a jungle shrub, Hakgala, April 1919.

Septobasidium Petchii Couch, in Couch, 1938, p. 126.

Common at Nuwara Eliya and Hakgala on *Lasianthus* and *Cinnamomum ovalifolium*, also found on *Litsea*, *Psychotria elongata* and *Murraya exotica*.

Septobasidium rimulosum Petch & Couch, in Couch, 1938, p. 102.

On tea, Pambagama, May 1918 (coloured figure in Petch, *Diseases of the Tea Bush*, Pl. 2); on tea, Talangaha, September 1928.

Septobasidium scabiosum Couch & Petch, in Couch, 1938, p. 286.

On leaves of *Codiaeum variegatum*, Royal Botanic Gardens, Peradeniya, 1910, and on the same bush, January 1912.

Septobasidium Theae Boed. & Stein.

On tea, Kempitiya, October 1905; Ratwatte Estate, 28 August 1928.

Helicobasidium compactum Boed.

At the base of the stem of *Clerodendron fragrans*, Peradeniya, October 1918; on an exposed *Hevea* root, Henaratgoda, January 1919.

Gymnoconia Patouillardi Trotter

On *Alchemilla indica*, Nuwara Eliya, 2 June 1928.

? Puccinia Anaphalidis (Miyabe) Sacc. & Trott. Aecidium and Uredo.

On *Anaphalis zeylanica*, by the lake, Nuwara Eliya, 13 May 1927.

Uredo Ophiopogonis Syd.

On *Ophiopogon intermedius*, Nuwara Eliya, 24 April 1927.

Entomophthoraceae

The following list includes all the Entomophthoraceae found in Ceylon up to the present.

Empusa Aulicae Reich.

Previously recorded (*Ann. Perad.* VII, 297) on larva of *Agrotis*, Peradeniya, January 1918. Also found on undetermined larvae, Peradeniya, June and August 1921, December 1922; Mahagalla, on larva of Tea Tortrix (*Homona coffearia*), 2 September 1928. On larvae of *Agrotis* on grasses, by the side of the lake, Nuwara Eliya, April 1927–May 1928, especially in May and June.

Empusa papillata Thaxt.

Previously recorded (*Ann. Perad.* VI, 297) on a fly, Peradeniya, December 1914. Also on flies, Suduganga, December 1919; Hakgala, March 1922, February 1928.

Empusa apiculata Thaxt.

Previously recorded (*Ann. Perad.* IX, 317) on a fly and a wasp, Vavuniya, December 1923.

Empusa apiculata var. *major* Thaxt.

On a beetle, Nuwara Eliya, 17 August 1927.

? Empusa Jassi Cohn.

On a membracid on *Albizzia*, Nuwara Eliya, August 1926; on a leaf-hopper (*Tettigoniella spectra*) on rice, Southern Province, January 1928.

I have included these collections provisionally under this name, but practically nothing is known about *Empusa Jassi*, except that, *teste* Schroeter, the mycelium (? conidiophores) forms a velvety white covering over the insect and the spores are globose, 20μ diameter. It occurred on *Jassus sex-notatus* at Breslau. The Ceylon species is attached to the plant by numerous rhizoids and has branched conidiophores, and is therefore an *Entomophthora*. The conidiophores appear in white lines and tufts along the sutures and ultimately become brown. The conidia are globose or oval, with a broad papilla, 28–44 × 20–34μ, and the conidiophores stout, up to 25μ diameter, the final branches being clavate. The conidia differ in shape from those of *E. papillata*, and they are not apiculate as in *E. apiculata*.

Empusa Fresenii Nowak.

On *Lecanium viride*, Peradeniya, 10 October 1913, 5 November 1913, August 1924; on a scale insect on *Cinnamomum ovalifolium*, Hakgala, 27 February 1922. See *Trans. Brit. myc. Soc.* XI, 254–8 (1926) and XVI, 229 (1932).

Entomophthora americana Thaxt.

On flies. Maskeliya, 18 October 1915; Hakgala, August 1923; Dessford, 1 October 1926; Pundaluoya, October 1927.

Entomophthora dipterigena Thaxt.

On flies. Hakgala, March 1924; St Coombs, Talawakelle, October 1936.

Entomophthora echinospora Thaxt.

On a fly, Nuwara Eliya, 15 July 1928; on a beetle, Nuwara Eliya, 18 August 1928; on an earwig, Nuwara Eliya, 2 September 1928.

Entomophthora pyralidarum Petch, *Trans. Brit. myc. Soc.* XXI, 36 (1937).

On *Pyralidae*. Peradeniya, 25 December 1923; Vavuniya, December 1923; Kandy, January 1924.

Pyrenomycetes

Hyphonectria violacea (Schmidt) Petch.

On a *Didymium*, Nuwara Eliya, 10 July 1927. Ascospores oblong-oval or subfusoid, one-septate, hyaline, ends rounded, 6–8 × 2·5–3μ.

Hypomyces parvus Petch, n.sp.

Subiculum white or yellowish, byssoid; perithecia clustered, red, globose with a conical apex, or flask-shaped, 180–230μ high, 120–150μ diameter; asci cylindrical or cylindrico-clavate, about 60μ long, 3–4μ diameter, spores uniseriate overlapping, or biseriate, no paraphyses; ascospores hyaline, narrow oval or fusoid, slightly inequilateral, one-septate, both ends acute or the upper end obtuse, minutely warted, 10–12 × 2–2·5μ. On abjected sporangia of *Pilobolus*, with the conidial stage, *Dendrodochium tenue* Petch, Nuwara Eliya, 9 October 1927.

Subiculo albo vel flavescenti, byssoideo; peritheciis rubris approximatis, globosis supra conicis, vel ampullaceis, 180–230μ alt., 120–150μ diam.; ascis cylindraceis vel cylindraceo-clavatis, ca. 60μ long., 3–4μ diam., sporis uniseriatis imbricatis, vel biseriatis; ascosporis hyalinis, anguste ovalibus vel fusoideis, uniseptatis, utrinque acutis vel supra obtusis, minute verrucosis, 10–12 × 2–2·5μ.

Dendrodochium tenue Petch, n.sp.

Sporodochia orange yellow, circular, up to 1 mm. diameter, or larger and irregular by confluence, flat, very thin, waxy, surrounded by a white byssoid hypothallus, splitting on drying; conidiophores branched, the branches terminating in a cluster of narrow flask-shaped phialides, 8–10μ high, 1μ diameter below, forming a continuous yellow palisade layer; conidia apical, hyaline, continuous, narrow oval or oblong-oval, ends obtuse, 2–4 × 1–1·5μ. On abjected sporangia of *Pilobolus*, Nuwara Eliya, November 1927–September 1928.

Sporodochiis aurantiis rotundatis ad 1 mm. diam., vel confluentibus irregularibus, planis, tenuissimis, ceraceis, sicco rimosis, hypothallo albo byssoideo cinctis; conidiophoris ramosis, ramis in phialidibus paucis angusto-ampullaceis, 8–10μ alt., infra 1μ diam., terminatis; conidiis apicalibus, hyalinis, continuis, angusto-ovalibus vel oblongo-ovalibus, obtusis, 2–4 × 1–1·5μ.

Plenophysa adiposa Petch, *Ann. Perad.* IX, 323 (1925).

The basis of this alleged species is a *Pilobolus* sporangium, and the description relates chiefly to the latter. The name should be discarded.

Ophionectria muscivora Petch, n.sp.

Perithecia scattered, or in clusters of two or three, conoid, 0·3 mm. high, 0·25 mm. diameter, pale red, subtranslucent, clothed nearly to the apex with loose white hyphae, 3μ diameter, which spread out radiately in a byssoid patch over the substratum; upper part of the perithecial wall bearing short hairs, cylindrical with an inflated tip, 20μ high, 5μ diameter below, 6–8μ diameter above, or oval cells, up to 16 × 8μ, sometimes one-septate; asci cylindrico-clavate, about 280 × 12μ, wall not thickened above, eight-spored, spores in a parallel bundle; ascospores hyaline, linear, multiseptate, one end truncate, tapering to the other obtuse end, about 240 × 3μ; pseudoparaphyses shorter than the asci, strap-shaped, broad, irregular. On moss on tree trunks, Nuwara Eliya, 19 June 1927.

Peritheciis sparsis, vel in gregibus parvis congregatis, conoideis, 0·3 mm. alt., 0·25 mm. diam., pallide rubris, subtranslucentibus, mycelio albo laxe ad apicem vestitis, mycelio in bysso substratum percurrenti; pariete supra crinibus brevibus, cylindraceis, apice inflatis, 20μ alt., infra 5μ diam., supra 6–8μ diam., vel cellulis ovalibus ad 16 × 8μ, interdum uniseptatis, ornato; ascis cylindraceo-clavatis, ca. 280 × 12μ, apice non incrassato, octosporis, sporis parallelis; ascosporis hyalinis, linearibus, multiseptatis, uno fine truncatis, altero attenuatis, ca. 240 × 3μ; pseudoparaphysibus ascis brevioribus, ligulatis, irregularibus.

Ophionectria uredinicola Petch, n.sp.

Perithecia gregarious, two or three on each uredo sorus, globose, up to 0·2 mm. diameter, yellow-brown, with a dark red, conical ostiolum, clothed with tawny, thick-walled, regular hyphae, 2–2·5μ diameter, which spread out over the sorus and the leaf; wall of small polygonal cells, 6–8μ broad; asci clavate, with a distinct foot, 60–75 × 8μ, thick-walled above but not capitate, eight-spored, spores in a parallel bundle; paraphyses linear, longer than the asci, diffluent; ascospores narrow lanceolate or subarcuate, straight or curved, attenuated above, strongly attenuated below, ends obtuse, five to eight septate, 30–40 × 3–3·5μ. On a Uredo on *Arundinaria debilis*, Nuwara Eliya, 9 August 1928.

Peritheciis gregariis, globosis, ad 0·2 mm. diam., flavo-brunneis, ostiolo conico, rubro, hyphis fulvis crasso-tunicatis, regularibus, 2–2·5μ diam., vestitis, hyphis bysso sorum obducentibus; pariete microparenchymatico, cellulis 6–8μ lat.; ascis clavatis, distincte pedatis, 60–75 × 8μ, pariete supra incrassato, non capitatis, octosporis, sporis parallelis; paraphysibus linearibus, ascos superantibus, diffluentibus; ascosporis anguste lanceolatis vel subarcuatis, rectis vel curvis, supra attenuatis, infra valde attenuatis, obtusis, 5–8-septatis, 34–40 × 3–3·5μ.

Ophionectria anomala Petch, n.sp.

Perithecia blood red, subtranslucent, in small groups on a scanty, fulvous, byssoid mycelium, ovate, somewhat contracted above, apex truncate, 0·45 mm. high, 0·2 mm. diameter; wall minutely rough with slightly projecting cells, thick, small-celled parenchymatous, red-brown on the exterior, hyaline on the interior; asci cylindrico-clavate, 180–250 × 14μ, eight-spored, apex capitate; ascospores cylindrical, tapering to the ends, multiseptate, with septa 7–9μ apart, about two-thirds the length of the ascus, 3–4μ diameter, in a parallel bundle, overlapping in the middle. Disorganized matter in the perithecium appears to be disintegrated asci, not paraphyses. On a dead bamboo (*Arundinaria*), Nuwara Eliya, 29 July 1928.

Peritheciis sanguineis, gregariis, mycelio sparso fulvo byssoideo insidentibus, ovatis, supra leniter contractis, truncatis, 0·45 mm. alt., 0·2 mm. diam., minute rugosis; pariete crasso, microparenchymatico, externe rubro-brunneo, interne hyalino; ascis cylindraceo-clavatis, 180–250 × 14μ, octosporis, apice capitato; ascosporis hyalinis, cylindraceis, utrinque attenuatis, multiseptatis, septis 5–9μ distantibus, 120–160 × 3–4μ, parallelis.

The position of this species is doubtful, as the apex of the ascus is capitate, i.e. forms a solid hemispherical cap with a flat base, partly penetrated by a narrow central canal, as in *Hypocrella*, *Barya*, *Torrubiella*, etc. In the type species of *Ophionectria*, *O. trichospora*, the apex of the ascus is not thickened, while in other species which have been placed in the genus the wall of the ascus increases in thickness from varying heights up to and over the apex, but the apex is not capitate. This second type of ascus might be called tunicate, but that term appears to have been used for the first type, and it is not possible to decide from the published descriptions which type of ascus is meant. *Ophionectria agaricicola* (Berk.) Sacc. was said by Saccardo to have a tunicate apex to the ascus, but von Höhnel and Weese in *Ann. Myc.* VIII, 465 (1910) placed it in *Barya*, and in *Fragmente* no. 1162 von Höhnel stated that the apex of the ascus was hemispherical and solid, i.e. capitate.

Following the example of Möller, this species might be placed in *Oomyces*, as similar to *Oomyces monocarpus* Möller, but although the wall of the perithecium is thick it cannot be regarded as a stroma. Most of the species which have been described as *Oomyces* do not belong to that genus, and some, e.g. *Oomyces javanicus* v. Hoehn. and *O. Ichnaspidis* (Zimm.) v. Hoehn., do not appear to differ in structure from *Podonectria coccicola* (Ell. & Everh.) Petch. In the type species, *Oomyces carneoalbus*, the apex of the ascus is rounded but not thickened, and the asci are accompanied by paraphyses. The only other species included in Saccardo up to the present which appears to agree with the type is *Oomyces Langloisii* (Ell. & Everh.) Seaver.

Mycocitrus hypocrellicola (P. Henn.) v. Hoehn.

On bamboo (*Arundinaria debilis* Thw.), Nuwara Eliya, October 1926.

This was described by Hennings as *Nectria hypocrellicola* (1902), but it is not a *Nectria* parasitic on a *Hypocrella*, and was transferred to *Mycocitrus* by von Höhnel in *Ann. Myc.* VIII, 466 (1910). It should be compared with *Hypocreopsis Phyllostachydis* Miyake & Hara (1912). The latter authors write *Hypocreopsis Phyllostachydis* (Syd.) Miyake & Hara on the supposition that their species is the one described by Sydow in 1900 as *Ustilaginoidea Phyllostachydis*, but it seems scarcely possible that Sydow described the same fungus.

Stereocrea Schizostachyi Syd.

On bamboo (*Arundinaria debilis* Thw.), Nuwara Eliya, October 1926.

Caliciopsis Symploci Fitzpatrick, *Mycologia*, XXXIV (1942), 511.

On leaves and young twigs of *Symplocos obtusa*, Sita Eliya, March 1922, April 1923.

The two collections were made from the same tree, which stood at the edge of the jungle, where the stream which crosses the Badulla road just below the Sita Eliya bungalow emerges from the jungle.

Deuteromycetes

Pycnidiella resinae (Ehrenb.) v. Hoehn.

On dwarf shoots on dead fallen branches of *Pinus*, Nuwara Eliya, July 1927.

Leptostromella Swertiae Petch, n.sp.

Spots definite, brown; pycnidia amphigenous, circular, black, scattered, immersed, subepidermal, becoming prominent, up to 120μ diameter, rupturing the epidermis irregularly and disclosing a thin, membranous, fuscous, parenchymatous, not radial, astomate cover which dehisces irregularly, leaving a black, parenchymatous ring surrounding the mass of sporidia; sporophores short, linear, about 10μ long, arising chiefly from the ring; sporidia hyaline, linear, straight or flexuose, one-septate, sometimes three-septate, 20–40 × 1·5μ. On leaves of *Swertia zeylanica* (Gentianaceae), Nuwara Eliya, 23 August 1927.

Maculis circumscriptis, brunneis; pycnidiis amphigenis, rotundatis, nigris, sparsis, immersis, subepidermalibus, demum prominentibus, ad 120μ diam., epidermidem irregulare frangentibus et scutum tenue, membranaceum, fuscum, parenchymaticum, astomum, exhibentibus, scutis irregulare dehiscentibus, annulum nigrum parenchymaticum remanens; sporophoris brevibus, linearibus, ca. 10μ longis, praecipue ex annulo oriundis; sporidiis hyalinis, linearibus, rectis vel flexuosis, uniseptatis, interdum triseptatis, 20–40 × 1·5μ.

Oidium sp.

On *Polygonum minus*, Nuwara Eliya, 29 September 1928.

Myxomycetes

The following species have been kindly identified, or the identification confirmed, by Miss G. Lister.

Badhamia versicolor Lister.

On moss on tree trunk, Nuwara Eliya, July 1927.

Physarum conglomeratum Rost.

Nuwara Eliya, September 1927.

Diderma ochraceum G. F. Hoffm.

Nuwara Eliya, 12 June 1927.

Diachaea cerifera G. Lister.

Nuwara Eliya, 9 January 1927.

Didymium melanospermum var. *minus* Lister.

On leaves of bamboo, Nuwara Eliya, 4 December 1926.

Trichia verrucosa Berk.

On a dead stump by the path to the Lady's Waterfall, Nuwara Eliya, 6 March 1927; September 1927.

Trichia alpina Meylan.

Nuwara Eliya, September 1927.

Hemitrichia vesparium Macbr. var. *globosa* G. Lister & Petch, n.var.

Sporangia globose or laterally ovoid, stalked, scattered or with stalks fasciculate in small groups of three or four: wall and capillitium as in the type; spores similar but rather larger, 13–15 μ diam.

On decaying stem of Mountain Papaw (*Carica candamarcensis*), Nuwara Eliya, June 1927.

Addendum

Sterigmatocystis monilifera (B. & Br.) Petch.

In *Ann. Perad.* VI, 179 (1916) I stated that *Periconia monilifera* B. & Br., Fungi of Ceylon, no. 893 (Thwaites 246), and *Aspergillus flavidus* B. & Br., Fungi of Ceylon, no. 913 (Thwaites 244) were both *Sterigmatocystis*, and that the slight differences between them might prove inconstant. Later investigation showed that these were not only the same species on the same host (a seed with a shiny brown coat), but also parts of the same gathering. In Herb. Peradeniya, Thwaites no. 244 is labelled *Aspergillus flavidus*, and Thwaites no. 246, *Helminthosporium gigasporum*, Fungi of Ceylon, no. 882. Herb. Kew. has the type of *Aspergillus flavidus*, with the Thwaites duplicates. The only specimen of *Periconia monilifera* is in Herb. Mus. Brit., *ex* Herb. Broome, where there is no specimen of *Aspergillus flavidus*, and this specimen is marked by Broome: 'Ceylon 246, no. 893 in Linnean Journal, but [Linnean Journal] 882 is also no. 246.' Evidently the specimen was sent to Broome under the wrong Thwaites number. Broome drew the figure of *Periconia monilifera*, which is, somewhat obscurely, that of a *Sterigmatocystis*.

Sterigmatocystis monilifera has yellow, fasciculate conidiophores, with stalks up to 50 μ diameter, usually encrusted, a receptacle up to 150 μ diameter, strongly pitted, prophialides cylindrico-clavate, up to 60 μ long, 6 μ diameter, phialides clavate, conoid above, with a truncate apex, up to $18 \times 4\mu$. The conidia are pale yellow, catenulate, echinulate, globose, 3–6 μ diameter, or oval, $4–6 \times 3–5\mu$, or ovate, $6–8 \times 5\mu$.

Sterigmatocystis vitellina Ridley, which should have been attributed to Massee, is the same species. It occurred on 'the fallen pericarps' of an undetermined fruit at Singapore. Massee's measurements are unaccountably small. In the type, the stalks of the conidiophores are up to 120 μ diameter, the receptacle up to 300 μ diameter, the prophialides $36–70 \times 7–9\mu$, and the phialides $12–20 \times 5–7\mu$. The conidia are usually irregular, as though immature, either cuboid or irregularly ovoid, $5–9 \times 3{\cdot}5–7\mu$, or ovate, $7–8 \times 3–4\mu$.

This species usually grows on seeds. Massee described and figured it as forming erect coremia, a misinterpretation natural for anyone who had not seen it growing. It is not an erect coremium, but a pencil of conidiophores lying flat on the ground or on the seed, only the apices of the individual conidiophores curving upwards. On a discoid seed, like that of *Strychnos Nux-vomica*, which lies flat on the ground, the pencils radiate in star fashion from the margin, in contact with the soil. On the more or less ovoid seed of *Hevea brasiliensis*, the fungus has been found to emerge through the micropyle and run backwards in a dense, narrow band, closely applied to the seed coat.

Blochwitz, in *Ann. Myc.* XXVIII, 246–7 (1930), stated that *Sterigmatocystis vitellina* was *Aspergillus flavus*. That does not appear to be correct. Thom and Church, *The Aspergilli*, wrote that, disregarding the coremia, *Sterigmatocystis vitellina* would fit in the *Aspergillus sulphureus* group, but while interlacing masses and ropes of mycelium are occasionally encountered, no *Stilbum* or *Isaria* coremia have been seen in *Aspergillus* except as reported by Ridley. As already indicated, the groups of conidiophores of *Sterigmatocystis vitellina* are not coremia, but rather 'interlacing masses'.

In Herb. Kew. there is a West African specimen agreeing with this species, labelled *Penicilliopsis Dybowskii* Pat. The latter species was described from decaying seeds in the Congo as having *Sterigmatocystis* conidiophores, but yellow-brown spores, and the Kew specimen is apparently misidentified. *Penicilliopsis Dybowskii* and similar (?) brown-spored species on seeds from South America, Africa and Java were placed by Hennings in a new genus, *Stilbothamnium*. von Höhnel dealt with that genus in *Fragmente zur Mykologie* no. 672 (1911), but he did not see the type species, *Stilbothamnium togoense*, during his revision of Hennings' types (*Ann. Myc.* IX, 172, 1911). Hennings described the conidiophore of that species as like that of *Sporocybe*, but von Höhnel considered that probably incorrect. In the absence of that type specimen nothing more can be done. Most of the other species placed in *Stilbothamnium* appear to have *Sterigmatocystis* conidiophores. The conidiophore of the type species of *Penicilliopsis* is different, and was correctly figured by the author of that genus, Solms-Laubach.

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ADDITIONAL NOTES ON BRITISH HYPOCREALES

By T. PETCH

In *Notes on Entomogenous Fungi*, *Trans. Brit. myc. Soc.* XXVII, 81–93, I recorded *Torrubiella albolanata* Petch, on spiders, *T. albotomentosa* Petch, on a dipterous pupa, and *Cordyceps tuberculata* (Lebert) Maire, on lepidopterous pupae, which were additions to the British list of Hypocreales. I have now to add an *Ophionectria*, *O. paludosa* (Crouan) Sacc., an actual occurrence of *Nectria Solani* Reinke & Berthold, and some details of species previously recorded or in dispute.

Nectria Solani Reinke & Berth.

In *Trans. Brit. myc. Soc.* VI, 105 (1919), Dr G. H. Pethybridge noted that for years in English phytopathological literature this fungus was credited, quite erroneously, with being the cause of the dry rot of the potato tuber, but he had never come across it and there was no reliable record of its occurrence in the British Isles. I did not find any specimens in British Herbaria when preparing *British Hypocreales*. Recently, Mr W. G. Bramley has sent me specimens from Pallathorpe, Yorks. On 23 May 1943 he wrote, 'While sorting potatoes over the other day... I took home one or two of the rotten ones.... On some of the wetter ones there was a golden yellow mould, and amongst this I found what appeared to be perithecia. Further examination proved them to be so, and I came to the conclusion that they were *Nectria Solani*.' Mr Bramley sent me further specimens on 9 June 1943.

Reinke and Berthold (*Die Zersetzung der Kartoffel*, Berlin, 1879) described the perithecia as crowded on an erumpent fleshy stroma. They stated that in its incompletely developed condition the stroma consists of interwoven hyphae, in the lower part mostly perpendicular to the surface of the potato, but often permeated by single hyphae or strands of hyphae running obliquely. Later the cells of the hyphae increase in thickness, and so form a pseudoparenchymatous tissue without air spaces, like a sclerotium. There is no definite cortex, but some of the outer cell layers are slightly darker. How much of this refers to development in nature and how much to growth in culture is not stated. Schroeter, who also grew it in culture, described the stroma as effused or pulvinate, fleshy (*Krypt.-Flora Schlesien*, Bd. III, zweite Hälfte, 260). In the present specimens, the perithecia in the first collection are seated on a byssoid stroma; in the second collection they are on erumpent pulvinate masses of hyphae, but as far as observed the hyphae do not form a pseudoparenchymatous tissue. These masses are composed of interwoven hyphae, traversed obliquely by strands or fascicles of hyphae, and are soft, yellowish internally at the base, dark red above, blackish externally. The red colour is removed by dilute alcohol. Probably under other conditions, the stromata would become pseudoparenchymatous.

The perithecia are dull yellow or reddish, the yellow specimens becoming

almost white, scattered or gregarious, globose, 0·3–0·4 mm. diameter, with a minute, inconspicuous, conical ostiolum, at first minutely rough, the wall composed of large cells up to 20μ diameter, smooth and rigid when old. The asci are narrow clavate, with a truncate apex, 63–72 × 6–8μ, the spores obliquely uniseriate, or biseriate above, uniseriate below. The ascospores are narrow oval, slightly inequilateral, not constricted at the septum, hyaline, becoming minutely rough, 10–13 × 4–5μ, sometimes 16 × 5μ. Schroeter stated that when old the ascospores were pale brownish.

On these specimens there also occurred minute white tufts of conidiophores, scattered or gregarious. These are the conidial stage figured by Reinke and Berthold, who referred it to *Spicaria Solani* de Bary. The main stem of the conidiophore is up to 8μ diameter, smooth, septate, branching widely below, and bearing towards the apex short suberect lateral branches. Conoid phialides are borne in whorls at the nodes and in clusters at the apices of the main stem and branches, all attaining approximately the same level. The conidia are oval, 5–6 × 3–4μ, with some globose, 3μ diameter, hyaline, smooth, those from adjacent phialides remaining adherent in a globose or irregular mass supported by the phialides. This is a *Gliocladium*, which must stand as **Gliocladium Solani** (Harting) Petch.

Reinke and Berthold (1879) employed the name *Spicaria Solani* de Bary, citing de Bary, *Die gegenwärtig herrschende Kartoffelkrankheit*, etc. (1861), p. 43. But de Bary took the name from Harting (1848), as also did Schacht (1856). In *Syll. Fung.* IV (1886), 167, Saccardo recorded that, according to Frank, *Spicaria Solani* Harting is *Acrostalagmus cinnabarinus*, but both de Bary and Schacht were dealing with a white species, and it seems scarcely credible that they should have adopted for it the name of a distinctly red species. Frank was probably mistaken. De Bary's description and figure indicate a *Gliocladium*.

Under *Nectria Solani* Reinke & Berth. in *Syll. Fung.* II (1883), 511, Saccardo stated that its conidial stage was a *Verticillium*, and ignored altogether Reinke and Berthold's very full account. Saccardo had previously described *Verticillium candidulum* Sacc. var. *Solani* Sacc., on rotting potatoes in France, in *Michelia*, II (1882), 637, with conidia, 6–6·5 × 3–3·5μ. The type of *V. candidulum* occurred on decaying rose fruits, and most probably is not related to the potato species. In *Syll. Fung.* IV (1886), 167, under *Spicaria nivea* Harz, another potato species, Saccardo stated that *Spicaria Solani* Rivolta, *Parass. Veget.* (1884), 563, fig. 304, with solitary, ovoid conidia, 5–8 × 4μ, was a *Verticillium*, *V. candidulum* var. *Solani*. The latter is included again in *Syll. Fung.* XXII (1913) as *V. candidulum* var. *Solani* (Riv.) Sacc. It is possible that this is the same as *Spicaria Solani* Reinke & Berth., but *Spicaria nivea* Harz, which grew on putrescent cooked potatoes and had fusoid conidia, 5–8μ long with acute tips, in chains, is apparently different.

Nectria Pandani Tul.

Nectria Pandani Tul. is said to follow or accompany *Melanconium Pandani* Lév. on dying specimens of *Pandanus* spp. in greenhouses in temperate climates. Schroeter, in *Krypt.-Flora Schlesien* (1894) gave a good account

of the *Nectria* and its hyphomycetous conidial stage from specimens on *Pandanus odoratissimus* in the Palm House of the Botanic Gardens at Breslau, and in 1895 he published a paper, *Ueber die Stammfäule d. Pandaneae*, in *Cohn's Beitr. z. Biol. d. Pflanzen*, Bd. 1. In a footnote under *Nectria Pandani* in Tubeuf and Smith, *Diseases of Plants*, etc., p. 188 (1897), Dr William G. Smith wrote, 'During the investigation of a case of a *Pandanus* killed in the Palm House at the Edinburgh Botanic Garden, J. H. Burrage found both forms present and agreeing in order of development with Schroeter's observations'. Presumably that means the *Melanconium* and the *Nectria*.

According to von Höhnel and Weese in *Ann. Myc.* VIII (1910), 467, *N. Pandani* Tul. (1865) is a form of *Nectria ochroleuca* (Schwein.) Berk. (1832). The conidial stage described by Schroeter (1894) agrees with *Verticillium tubercularioides* Speg., the conidial stage of *N. ochroleuca*.

Lasionectria Leptosphaeriae (Niessl) Petch

Mr E. A. Ellis collected this species, with its conidial stage, *Fusarium Sphaeriae* Fckl., at Old Lakenham, 8 January 1942, on a *Leptosphaeria* and its *Phoma* stage, apparently *L. acuta* (Hoffm.) Karst. and *Phoma acuta* Fckl., on nettle. As Mr Ellis pointed out, the *Fusarium* appears to be only on the *Phoma*. The *Fusarium* stromata are pulvinate, with a pseudostalk in the ostiolum of the *Phoma*, pinkish, fading to almost white, parenchymatous and orange at the base; the conidia are uniformly curved, or straight, or almost straight with falcate tips, five-septate, 50–63 × 5–6 μ. The ascospores of the *Lasionectria* are narrow oval or oblong oval, sometimes curved, 16–21 × 6–7 μ, or with one cell inflated, 16–23 × 7–9 μ.

Niessl described *Nectria Leptosphaeriae*, on a *Leptosphaeria* on *Urtica*, as having ascospores, 15–17 × 4–5 μ, but Weese, *Hypocreaceen*, 1, 72 (1916), examined the type and found them 15–22 × 5–6·5 μ. Fuckel, in *Symb. Myc.* p. 370, described *Fusarium Sphaeriae*, on *Leptosphaeria doliolum* on nettle, as having conidia 3 to 5 septate, 54–60 × 4 μ. Wollenweber, in *Angew. Bot.* VIII, 187 (1926) described a form of *L. doliolum* on *Urtica* as var. *macrospora* Wollenw., giving the ascospores as 15–31 × 5–7 μ (usually 19–25 × 5·8–6·5 μ) and the *Fusarium* conidia as 3 to 5 septate, 45–73 × 4·5–5·5 μ, and stating that it differed from the type in its larger ascospores and smaller conidia.

Calonectria nivalis Schaffnit

The perithecial stage of *Fusarium nivale* (Fr.) Ces., parasitic on turf grasses, has been known for about thirty years, but there is still confusion about its name. The evidence was summarized by Weese in 1914, and the following details are based on his account.

Ihssen (1910) believed that he had proved that the ascigerous stage of *F. nivale* was *Nectria graminicola* B. & Br., but Weese (1913) examined his original material and found that the perithecial fungus was not a *Nectria*, but an epidermal *Leptosphaeria* or *Metasphaeria*.

Wollenweber (1913) investigated the disease caused by *F. nivale* and obtained a *Calonectria*; and followed Ihssen in assigning it to *Nectria*

graminicola B. & Br., changing the name to *Calonectria graminicola* (B. & Br.) Wollenw.

Schaffnit (1913) who also investigated this disease, obtained a *Calonectria*, which he described as *Calonectria nivalis* Schaffnit. It is agreed that this is the same species as Wollenweber's.

From the descriptions, *C. nivalis* is not *N. graminicola* B. & Br. The latter has apparently been collected only once. The type shows scattered superficial perithecia, each seated on a small brown basal membrane, with one-septate ascospores, 16–20 × 3·5–4·5 μ. *C. nivalis* is described as having ascospores, 12·5–16 × 2·5–3·5 μ, one-septate, rarely two-septate.

The Plant Pathology Committee of the British Mycological Society adopted the name, *C. graminicola* (B. & Br.?) Wollenw., but in the *List of Common British Plant Diseases* (1944) they changed that to *C. graminicola* Wollenw., while in the introduction they wrote, '*Calonectria graminicola* is here attributed to Wollenweber, even though he thought that he might be transferring Berkeley and Broome's *Nectria graminicola*. (It might have been even better to accept *Calonectria nivalis* Schaffnit, which from its inception was definitely associated with the Snow Mould disease of cereals.)' It is apparently agreed that Wollenweber made a mistake. But unless he described his fungus independent of any reference to B. & Br., there is no such species as *Calonectria graminicola* Wollenw.

In Saccardo, *Syll. Fung.* XXIV, 681, the name is given as '*Calonectria nivalis* Schaffnit, *Nectria graminicola* B. & Br., saltem p.p.' But as the type of *Nectria graminicola* B. & Br. was not a mixture, 'saltem p.p.' is meaningless.

The relevant literature is:

Ihssen, — (1910). *Zbl. Bakt.* II Abt., Bd. XXVII, 48–66.
Schaffnit, E. (1911). *Jb. wiss. Bot.* IX, 39–51; *Landw. Jb.* XLIII.
Schaffnit, E. (1913). *Mykol. Zbl.* II, 253–8.
Weese, J. (1913). *Z. GärPhysiol.* II, 290–302.
Weese, J. (1914). *Ann. Myc.* XII, 137.
Wollenweber, H. W. (1913). *Phytopathology*, III, 24–52, 197–242.

It would seem advisable that some alteration should be made in the rules of nomenclature to permit the rejection of transferred names based on misidentifications. In many cases these are distinctly misleading. The addition of an author's name enables one to look up information about the species, but anyone who consults Spegazzini's description of *Hypocrella phyllogena* (Mont.) Speg. for information about *Hypocrea phyllogena* Mont. will get quite a wrong idea of the latter, because Spegazzini made a mistake in identification.

Attention may be drawn to the current practice of assigning or transferring to *Calonectria* any *Nectria* which shows ascospores, no matter how few, with more than one septum. The single septum of *Nectria* is a remarkably constant feature, but variations do occur. I have previously recorded (*Trans. Brit. myc. Soc.* XXIV, 44) the occurrence of ascospores with two and three septa in *Nectria cinnabarina*. But *N. cinnabarina* is the type species of the genus *Nectria*.

Ophionectria paludosa (Crouan) Sacc.

On 4 August 1942, Mr E. A. Ellis collected an *Ophionectria* on decaying stems of *Glyceria maxima*, in company with *Ciliospora albida* (Massee & Crossl.) Grove, at Old Lakenham, Norfolk. The perithecia are minute, scattered, superficial, attached to the substratum by repent hyphae from the base, ovate, about 0·25 mm. high, 0·2 mm. diameter, apex subtruncate, soft, pinkish white when fresh, becoming pale brown when dry, with a few scattered hairs on the upper part but sometimes almost naked. The hairs are pale or dark brown, rather closely septate, with an obtuse apex, and vary from about 45 μ long, 10 μ diameter at the base, soon diminishing to 7 μ diameter, to 120 μ long, 10 μ diameter below, soon diminishing to 5 μ, and thence almost equal up to the apex. When viewed as an opaque object, the basal mycelium and the hairs appear black. The wall of the perithecium is thin, yellow-brown by transmitted light, and irregularly cellular. The asci are cylindrico-clavate, thick-walled above but not capitate, 130–150 × 10–12 μ, eight-spored, and are accompanied by linear paraphyses, branched above, soon diffluent. The ascospores are up to 115 μ long, 3–4 μ diameter, linear-cylindrical, slightly attenuated at the ends, hyaline, multiseptate, with septa 4–6 μ apart.

This species appears to be *Ophionectria paludosa* (Crouan) Sacc., recorded by the Crouans in *Florule du Finistère*, no. 38 (1867) from specimens on decaying stems of *Rubus* and *Cirsium palustre*, and transferred to *Ophionectria* by Saccardo in *Michelia*, 1, 323. I have not been able to consult the original description, but that given in Saccardo, *Syll. Fung.* 11, 563, is 'Peritheciis ½ mill. diam., albo-carneis, ovoideis, reticulato-contextis; ascis cylindraceis, dehiscentibus, 8-sporis; sporidiis filiformibus, praelongis, multiguttulatis'. The species does not appear to have been recorded again, and as far as I can ascertain it has escaped revision by von Höhnel and Weese. The colour, shape and habitat agree with those of the Norfolk specimens. The size given may have been an estimate, not a measurement. The hairs on the perithecium are not mentioned, but they vary in number, and one perithecium examined bore only two.

Owing to the presence of paraphyses, this species would be included in *Tubeufia* on von Höhnel's classification. It does not, however, seem advisable to adopt the presence of paraphyses as a generic character in Nectriaceae in which paraphyses, as a rule, are evanescent; and as the hairs on the perithecium vary so much in number, it scarcely appears worth while to transfer this species to *Trichonectria*.

Barya aurantiaca Plowright & Wilson

For many years, Mr A. S. Wilson, of Aberdeen, made observations on the occurrence of ergot in Aberdeen and Kincardine shires, and he published a paper, *Observations and Experiments on Ergot*, in the *Transactions of the Botanical Society of Edinburgh*, Session 1875–6. In 1884 (*Gard. Chron.* 9 February, p. 176) he wrote, in association with Plowright:

'While ergot has been collected on many species of grass in all parts of

Britain the mature *Claviceps* or ascophore of which ergot is the stroma has been more rarely met with. Opportunities have therefore been wanting for observation of *C. purpurea* growing naturally, and as affected by environing circumstances. But the writers of this paper have found it in several localities in great abundance every year since 1874.... It is chiefly on the ergot of *Glyceria fluitans* R. Br. that the *Claviceps purpurea* has been found growing naturally, as above stated. At the bottom and on the sides of a half-dry ditch, where this grass is allowed to grow undisturbed, the ergots fall down in autumn and are covered by the decaying grass. The ditch runs east and west, and the purple *Claviceps* has been found mostly on the south or shady side.

'The early part of 1882 was very wet, and in July, when the fungus was looked for, very few specimens could be found; but in their place, and upon the same ergot, everywhere appeared white and yellow stipes, about the same height as those of the purple *Claviceps*. Last year (1883) they appeared again, but apparently intermixed with a larger proportion of the purple form. Whether they appeared first in this locality in consequence of climatic peculiarities, or whether they had been previously overlooked, it would not now be safe to say. Their conspicuous appearance is against the alternative that they were overlooked till 1882.'

Plowright and Wilson decided that the white or yellow fungus was parasitic on the *Claviceps*, and they described it as '*Barya aurantiaca* n.sp.—Stroma vertical, clavate or subcapitate, 10–20 mm. high by 1–3 mm. in diameter; when young floccose, white with conidiiferous hyphae, and bearing yellow perithecia with orange ostiola on its upper two-thirds. Conidia elliptico-lanceolate, borne in chains on the ends of branching conidiiferous hyphae, 10–12 × 2–3 μ [? spicarioid, T.P.]. Perithecia pyriform, yellow, almost free, with elongated necks which with the minute ostiola are orange, 250–300 × 150 μ. Asci cylindrical, 200–250 × 30 μ [error for 3 μ, T.P.]. Sporidia [ascospores] filiform, flexuous, continuous, as long as the asci. The base of the stroma springs from a floccose mass of yellowish white mycelium. On *Claviceps purpurea* on the ergot of *Glyceria fluitans*. Near Aberdeen. July.'

Plowright and Wilson gave a page of figures, and further figures were given by Worthington G. Smith in *Diseases of Field and Garden Crops* (1884). Smith regarded it as an abnormal form of *Claviceps purpurea*, and named it *C. purpurea* var. *Wilsoni*. He remarked that the clavae were less firm than the type, and many of the growths were hair-like, while others were attenuated upwards from a thicker base and did not bear perithecia. Meanwhile, specimens had been sent to Cooke, who described it in *Grevillea*, XII, 77, March 1884, as *Claviceps Wilsoni*. Stäger accepted *Claviceps Wilsoni* as a distinct species, but his account shows that he did not have Wilson's species.

In 1916, Oertegren described *Cordyceps clavicipitis*, on ergots on rye, in *Svensk Bot. Tidskr.* X, 57, the fungus having developed on the ergots in culture. In some instances, both *Claviceps purpurea* and the *Cordyceps* grew from the same ergot, in others only the *Cordyceps*, the former being suppressed. The description of *Cordyceps clavicipitis* agrees with that of *Barya*

aurantiaca in many details, especially in the long yellow or orange apex of the perithecium, but Oertegren described the ascospores as multiseptate.

Cordyceps clavicipiticola Tokunaga & Imai was described in *Trans. Sapporo nat. Hist. Soc.* XIV, 104 (1935). It occurred on ergots on *Sasa paniculata*, which were collected in September 1933 and produced the *Cordyceps* in May 1934. I have not seen the description, and unfortunately Kobayasi did not give any details.

It seems very probable that *Barya aurantiaca* and *Cordyceps clavicipitis* are the same species. The outstanding difference is in the description of the ascospores. It is not easy to decide whether ascospores of this type are continuous, or multiseptate, or multiguttulate, without staining. Plowright and Wilson, who had ample opportunities (see their account) of observing extruded ascospores from naturally-grown perithecia of the first-named, found the ascospores continuous, 'its sporidia are always continuous and never break up into joints as those of *Cordyceps* do'. I have only examined one specimen, Cooke's in Herb. Kew., and in the perithecium examined the asci were immature. There should be other specimens of Wilson's collection elsewhere.

More information is needed about the behaviour of long filamentous ascospores after extrusion. In experiments with *Claviceps purpurea*, which has continuous ascospores, these became septate in hanging drops of water before or during germination; and Möller found the same happened in *Claviceps balansioides*. It is conceivable that under artificial conditions the ascospores of *Barya aurantiaca* might become septate before extrusion.

In *The Naturalist*, February 1937, p. 27, I recorded that the head of *Claviceps purpurea*, when developed on ergots on sand and carefully watered so that the head was not wetted, remained cream-coloured or ochraceous. *Claviceps pusilla* Ces., on ergots on *Andropogon*, and *Claviceps setulosa* (Quél.) Sacc., on ergots on *Poa*, appear to be merely this condition of *Claviceps purpurea*.

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NOTES ON THE PATHOGENICITY OF *MYROTHECIUM RORIDUM* TODE EX FR.

By F. T. BROOKS, *Botany School, Cambridge*

Although the earlier mycologists considered that *Myrothecium roridum* was purely saprophytic, it has been shown more recently by Taubenhaus (1935) and Preston (1936) to be pathogenic to cultivated Antirrhinums and Violas respectively. Deighton (1936) records *M. roridum* as causing a leaf spot of *Hibiscus esculentus* and other tropical plants in Sierra Leone, the identification being subsequently confirmed by Preston (1943). Another species, *M. verrucaria*, collected by R. M. Nattrass from potato foliage in Cyprus, is stated by Preston (1943) to be a parasitic form.

In recent years the writer has isolated *M. roridum* from *Antirrhinum*, *Lupinus ornatus*, and potatoes growing at Cambridge, the determinations being kindly confirmed by Mr N. C. Preston. The cultures, which showed slight macroscopic differences on a variety of media, were obtained as follows:

(1) *Antirrhinum isolate*

In July 1939 a wilted *Antirrhinum*, with the outer stem tissues 3 in. upwards from the soil discoloured and partly rotted, showed the characteristic sporodochia of the fungus.

(2) *Lupinus isolate*

In August 1939 a withered plant of *Lupinus ornatus* was removed from my garden and kept moist in the laboratory. Numerous sporodochia of *M. roridum* developed on the underground parts.

(3) *Potato isolate*

In September 1942 the subterranean parts of the haulm and roots of Gladstone potatoes, which had died prematurely through eelworm attack, were kept moist in the laboratory. Sporodochia of *M. roridum* developed in abundance on the subterranean parts of the haulm.

Numerous inoculations of a variety of hosts with these isolates have been carried out. The following is a summary of representative experiments:

(1) 23 *August* 1939. The *Antirrhinum* isolate was placed in stem wounds made in two *Antirrhinum* plants in pots, 1 in. above soil level. Both plants wilted and died, and numerous sporodochia of *M. roridum* developed on the discoloured tissues around the place of inoculation. Control plants were unaffected.

(2) 10 *October* 1939. The *Antirrhinum* isolate was inoculated as above into stems of a great variety of plants growing in pots in a glasshouse. Plants of *Antirrhinum*, tomato (variety Kondine Red), *Viola* and sweet sultan all wilted and developed sporodochia. Plants of *Godetia*, *Matthiola*, *Clarkia*,

Petunia, *Gilia*, *Callistephus* did not wilt but showed extensive lesions with sporodochia. Plants of *Phlox drummondi* and *Zinnia* were quite unaffected. The control plants remained healthy.

(3) 12 *December* 1939. For these inoculations the *Antirrhinum* isolate was grown for several weeks on sterilized wheat grains. The wheat with the *M. roridum* was mixed with (*a*) sterilized and (*b*) unsterilized soil, into pots of which healthy young plants of various kinds were transplanted and kept in a heated glasshouse. Controls were kept both in sterilized and unsterilized soil.

In inoculated sterilized soil all plants of *Antirrhinum*, tomato (Kondine Red), sweet sultan, *Godetia*, and *Clarkia* wilted and died. After death the plants were examined and all showed numerous sporodochia of the fungus on the underground parts. The *Viola* plants partly wilted and some shoots died, but the plants subsequently recovered; sporodochia developed on the lower parts of the dead stems.

In inoculated unsterilized soil only *Antirrhinum*, tomato and *Viola* were experimented with. The *Antirrhinum* plants were killed and sporodochia developed on the subterranean parts. The tomato plants partly wilted and then recovered, no sporodochia developing. The *Viola* plants wilted and then partially recovered, sporodochia being present on the lower parts of stems which had been killed.

The control plants remained unaffected and did not wilt after transplantation.

(4) 24 *March* 1943. On this occasion a comparison of the pathogenicity of the three isolates from *Antirrhinum*, *Lupinus ornatus*, and potato respectively was made on the following hosts: *Antirrhinum*, tomato (Kondine Red) and potato (King Edward). Unsterilized soil mixed with wheat grains bearing an active culture of the fungus was used. Young healthy plants of *Antirrhinum* and tomato and potato tubers were placed in it and kept in a heated glasshouse.

With the *Antirrhinum* isolate the Antirrhinums were killed and bore sporodochia of the fungus, the tomato plants wilted but recovered, while the potato plants were quite unaffected.

With the *Lupinus* isolate the Antirrhinums were killed and bore sporodochia, the tomato plants wilted, died and bore sporodochia on the roots, while the potato plants were unaffected.

With the *potato* isolate there was not the slightest evidence of pathogenicity to *Antirrhinum*, tomato or potato.

(5) 6 *April* 1943. A comparison of the pathogenicity of the three isolates was made by inoculating wounds in stems of Antirrhinums and tomato and potato plants just above soil level.

With the *Antirrhinum* isolate the Antirrhinums were killed, sporodochia developing on the large discoloured lesions. The tomato plants wilted but recovered; considerable lesions with sporodochia developed round the place of inoculation. Only the slightest lesions formed on the potato stems and no spores were produced.

With the *Lupinus* isolate only slight lesions, unaccompanied by spores, were formed on the Antirrhinums. With the tomato plants the lower leaves

yellowed and fell off, considerable lesions developed with sporodochia, but finally the plants grew well. The potato plants were unaffected, only the slightest discoloration developing around the wounds.

With the *potato* isolate there was no evidence of pathogenicity.

Conclusion

It is clear, therefore, that these three isolates of *Myrothecium roridum* show differences in pathogenicity, the isolate from potato being entirely non-pathogenic to the hosts experimented with. Further, the isolate from *Lupinus ornatus* seems to be somewhat more pathogenic to tomato than the one from *Antirrhinum*. The earlier experiments outlined above show that the isolate from *Antirrhinum* is pathogenic to quite a wide range of host plants.

Summary

It has been shown that isolates of *Myrothecium roridum* from different hosts vary in pathogenicity, one from potato being apparently entirely non-pathogenic to the plants experimented with. An isolate from *Antirrhinum* was pathogenic to a wider range of hosts than has been recorded hitherto.

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PROCEEDINGS

Meeting held in the rooms of the Linnean Society of London, 19 February 1944.

The President, R. W. Marsh, M.A., in the Chair.

E. A. Ellis. The fungi of Wheatfen Broad, Norfolk.
Miss G. M. Waterhouse. The true nature of *Myrioblepharis* Thaxter.
Miss E. M. Blackwell. Species of *Phytophthora* as water moulds.
F. Bayard Hora. Some aspects and problems of the ecology of the agarics.
A. A. Pearson. Diagnostic characters of the agarics.

Meeting held in the Department of Botany, Imperial College of Science and Technology, South Kensington, 21 April 1944.

The President, R. W. Marsh, M.A., in the Chair.

Exhibits and Demonstrations

F. D. Armitage, Chlorazol black E stain; S. D. Garrett, Sclerotia of *Helicobasidium purpureum* on sugar beet and potato; Miss L. E. Hawker, Growth substances and fungi; C. T. Ingold, A new chytrid on *Ceratium hirundinella*; Miss J. Moore, Potato tubers rotted by *Fusarium avenaceum* and *F. coeruleum*; J. Ramsbottom, *Queletia mirabilis*.

Methods for recording Agarics

Miss E. M. Wakefield, Drawings; J. Ramsbottom, Kodachrome photographs; A. A. Pearson, Spore powders; Miss E. A. Jenkins and H. A. Hyde, Wax models from the National Museum of Wales; Cultures from the Mycological Section, Forest Products Research Laboratory; Preserved and dried specimens.

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